



Flowering phenology and airborne pollen grains of chosen tree taxa in Rzeszów (SE Poland)

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Abstract

The aim of the study was to compare the course of flowering and the occurrence of *Alnus*, *Corylus* and *Betula* pollen grains in the air in 1999–2001. In 2000 and 2001 birches flowered in a typical way – the flowering period was short and intense and that period had the highest concentration of pollen. Both years had no rainfall then and the temperature was high, which caused intense flowering of birches over a large area. In 1999 and 2000 most of the *Alnus* and *Corylus* pollen was recorded at the end or after their flowering period. At that time the weather was unstable (as is usual in February and March). Pollen must have been transported from elsewhere. Wind analysis showed that the main sources of *Corylus* pollen must have been in the south, and of *Alnus* in the south and west. In the southern margin of Poland the vegetative period begins later due to a colder climate.

1. Introduction

Aeropalynology and phenology study different natural phenomena, i.e., the occurrence of pollen in the air and the dynamics of the vegetative and generative changes of vegetation within a year. For pollen, in order to take part in the aeroplankton the plant must come to bloom and at this stage the two areas of science are interconnected (Edmonds 1979). By the presence of pollen of some species the oncoming flowering of other species may be predicted (Latorre 1997). In order to correctly evaluate the results of aeropalynological studies, knowledge of the duration and dates of phenological phases is required as well as the distribution of potential sources of pollen (Puppi Branzi and Zanotti 1992).

In this paper the results of aeropalynological and phenological studies of three allergenic genera (*Corylus*, *Alnus* i *Betula*) are present. Flowering and pollen seasons were compared in various years. The overlap between the two phenomena was estimated and a trial to localise the source of pollen was made. Another question asked was to what extent phenolo-

gical observations can be helpful in the preparation of pollen prognoses for people allergic to them.

2. Materials and methods

The study was carried out in Rzeszów, a city located in SE Poland (50°01'N, 22°02'E) at the altitude of 200–215 m above sea level. The climate of the Rzeszów region can be classified as transitional between the lowland-highland climate, which has warmer summers and autumns and relatively mild winters, and a mountain climate, which has shorter summers and frosty winters. The warmest month is July (17.6°C) and the coldest is January (–4.6°C). The vegetation growth period usually lasts for 215–220 days. The flora and vegetation of Rzeszów is strongly transformed by man. Vegetation is restricted mainly to parks, lawns and private gardens (Kiryk 1994).

The taxa chosen for study (*Alnus*, *Corylus* and *Betula*) are very common in the city and its vicinity and their pollen is a cause of inhalatory allergies.

Material for the analyses was collected over a three year period (1999–2001). Phenological observations were carried out from mid-January to mid-May in a few (5–7) places in the city which differed in environmental conditions (wind, insolation, humidity). In each site, a number of different plants (4–60) for each species were observed. On the basis of qualitative investigations three phenological phases were identified – beginning (10% of inflorescences flower), maximum (above 50% of inflorescences flower) and termination of flowering (last 10% of inflorescences flower) (Sokołowska 1980). Aeropalynological investigations were done using the volumetric method (1999–2000 – Burkard's apparatus, 2001 – Lanzoni's apparatus) throughout the year. The measurements and statistics conform to the IAA standards. The pollen season was estimated using the 90% method (Nilsson and Persson 1981). The relationship between wind direction and the mean number of pollen grains was analysed for each year separately and for all the years together. When using homogenic sampling (Leven's test), single factor ANOVA (one-way analysis of variance) was applied, otherwise the non-parametric Kruskal-Wallis. After finding a statistical significance ($p \leq 0.05$) the LSD *a posteriori* test was applied.

3. Results

The phenological observations were conducted in some sites, which differed in environmental factors. The dates of phenophases did not cover (2–4 days delay), so the phenological data presented in Table 1 are the average value.

Corylus – During the last three years three phenological times of the beginning of flowering of *Corylus avellana*, and also the time which the flowering season lasted, were significantly different. The earliest flowering began in 2001 and the flowering season was the longest. In 1999, flowering began the latest and lasted the shortest time (Table 1, Figure 1). The dates of the beginning of the pollen season differed significantly. The difference between years went up to 32 days. The pollen season was the longest in 2001 and the shortest in 1999, but despite this the SPI (Seasonal Pollen Index) values were very similar to each other (Table 1). Analysis of the relationship between wind direction and the average number of pollen grains in season showed statistical significance only in 1999. Single factor ANOVA (one-way analysis of variance) was applied ($F = 2.8012$, $p \leq 0.05$). After the *a*

posteriori test two differing groups of winds were distinguished – W, N, NNW, NE, ENE, E, SE, SSW, W, NW and S (in the latter group the mean pollen grain number was distinctly higher).

Alnus – Phenological observations were made of two species: *Alnus incana* i *A. glutinosa*. *A. incana* started and finished flowering latest in 1999. The difference between other years was three weeks. The flowering seasons were relatively short – 11–14 days. *A. glutinosa* showed smaller variation in its flowering dates. Flowering time oscillated from 16 days in 1999 to 20 in 2001 (Table 1). Both species of alders flowered at the same time only in 1999, in other years *A. incana* flowered two to four weeks earlier than *A. glutinosa* (Table 1, Figure 2). In three years of study, large differences were observed in dates of pollen seasons, their duration times and SPI values. In 2001, the pollen season was shortest, in spite of the fact that the SPI and MPA values were highest (Table 1). In the other years pollen seasons were much longer and the annual curves had two or three minima (Figure 2). Statistical analysis of the relationship between the direction of wind and the mean number of *Alnus* pollen grains showed a significant relationship only in 1999. The non-parametric Kruskal-Wallis test was applied ($H = 13.38411$, $p \leq 0.05$). As a result of the *a posteriori* test, two differing groups of winds were distinguished: NE, E, SE, SW, W and S, W, NW (in the latter group the mean number of pollen grains was higher).

Betula – The flowering time of birches was similar throughout the two years of observations (2000–2001). Flowering dates and the length of the flowering season differed only by several days (Table 1). Birch pollen grains were present in the air for a short time and in very large concentrations (Figure 3). The differences between SPI and MPA were quite large. In 2000, the SPI values was nearly three times higher than that for 2001 (Table 1). Analysis of variance (ANOVA) applied to test the relationship between the mean number of pollen grains and the direction of wind did not show any statistically significant results ($p \leq 0.05$).

4. Discussion

The chosen tree species form their inflorescences in the late summer of the proceeding year, and in autumn, when days get longer and temperatures drop, they become dormant. After that period when external

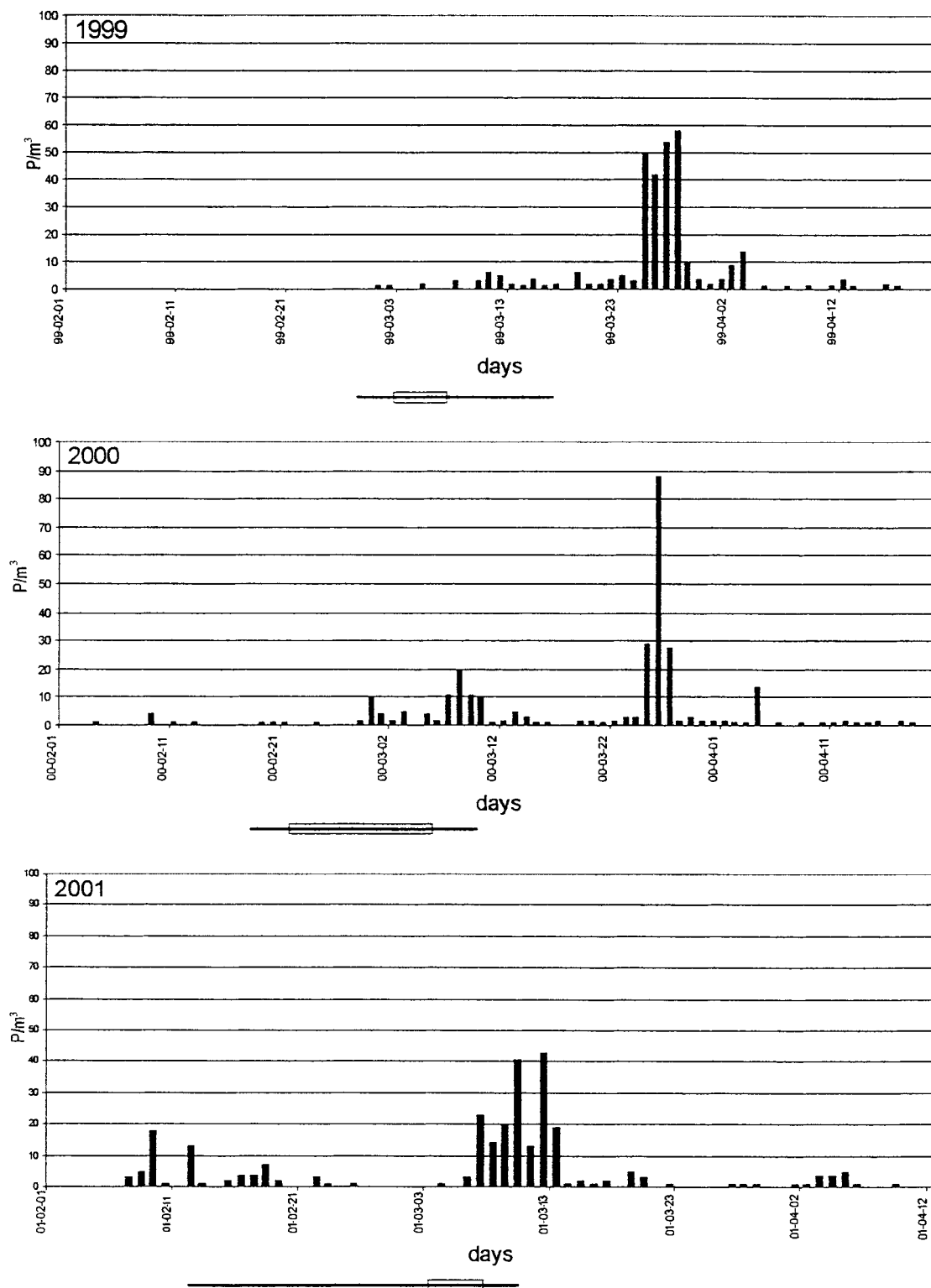


Figure 1. Flowering phenophases of *Corylus avellana* and airborne *Corylus* concentrations in 1999–2001 in Rzeszów phenophases (average data): start maximum end.

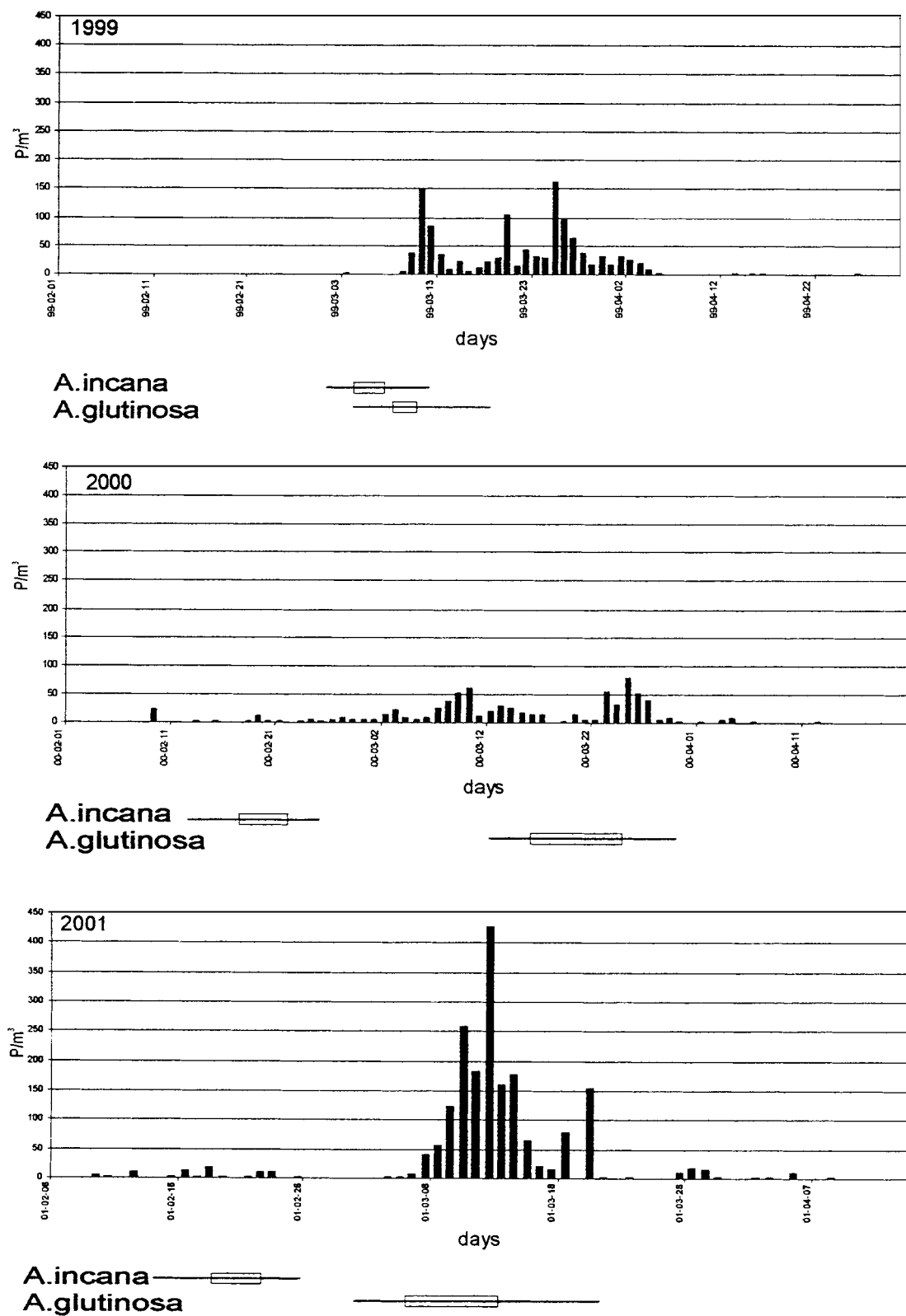


Figure 2. Flowering phenophases of *Alnus incana* and *Alnus glutinosa* and airborne *Alnus* concentrations in 1999–2001 in Rzeszów phenophases (average data): start — maximum — end.

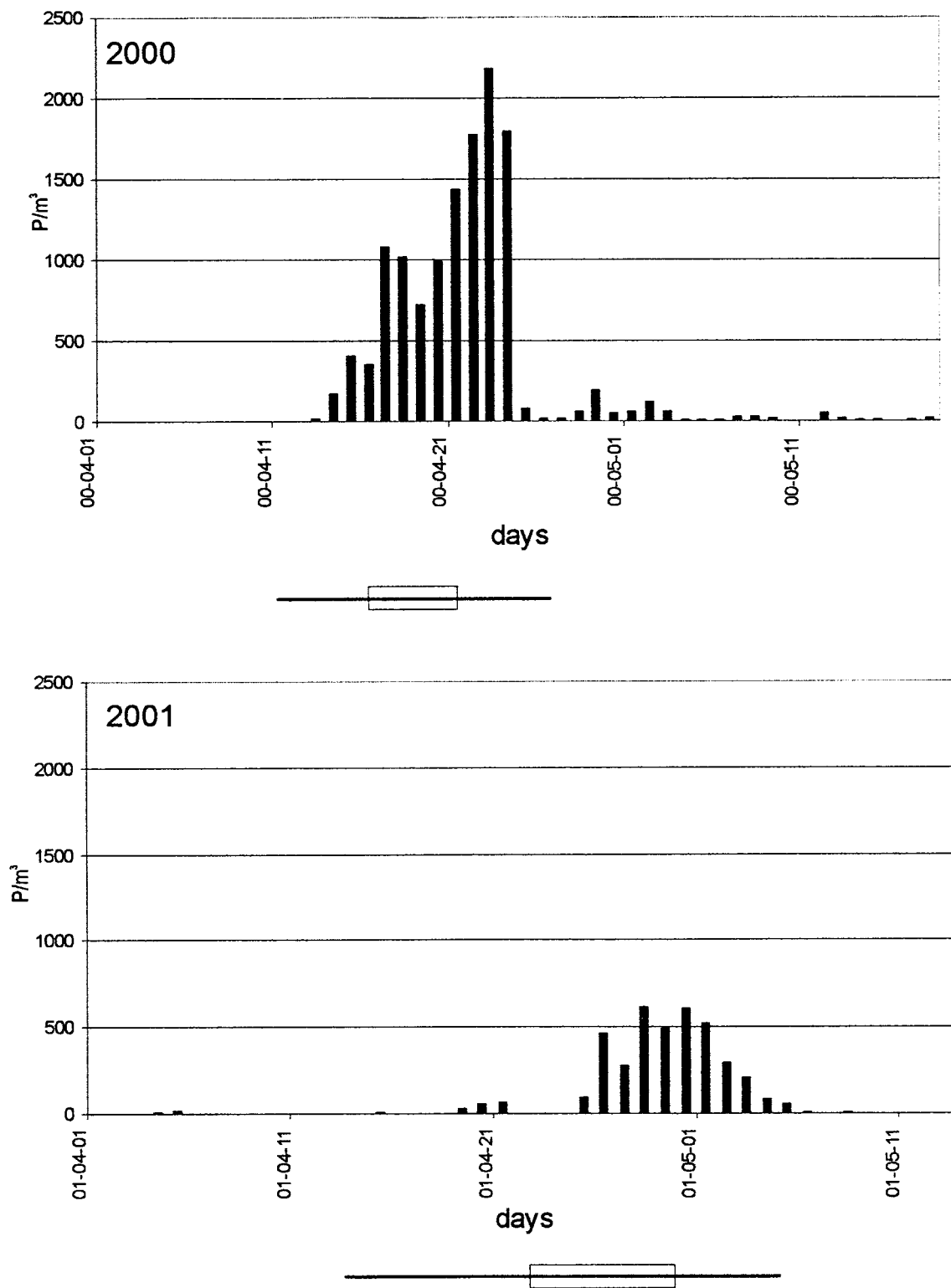


Figure 3. Flowering phenophases of *Betula pendula* and airborne *Betula* concentrations in 2000–2001 in Rzeszów
phenophases (average data): start [] maximum [] end.

Table 1. Flowering and pollen seasons – basic data (SPI – seasonal pollen index, MPA – maximum pollen appearance, pollen season – 90% method, flowering season – average data from all sites)

Taxon	Years	Flowering season			Pollen season			SPI	MPA/day
		start	end	duration	start	end	duration		
<i>Corylus</i>	1999	28.02	17.03	18	13.03	04.04	23	279	58/28.03
	2000	19.02	11.03	22	29.02	11.04	43	281	88/26.03
	2001	12.02	11.03	28	09.02	03.04	54	253	43/12.03
<i>Alnus</i> <i>*incana</i>	1999	*02.03	*12.03	11	11.03	02.04	23	1078	163/25.03
		°04.03	°19.03	16					
<i>°glutinosa</i>	2000	*12.02	*25.02	14	19.02	01.04	43	739	78/25.03
		°12.03	°30.03	19					
	2001	*15.02	*26.02	12	06.03	19.03	14	1619	427/12.03
		°02.03	°21.03	20					
<i>Betula</i>	2000	11.04	26.04	16	16.04	28.04	13	11554	2186/23.04
	2001	14.04	5.05	22	21.04	03.05	13	3640	612/28.04

conditions (especially temperature) become favourable cellular divisions, growth and flowering occur (Clutter 1978; Frenguelli et al. 1992).

Sokołowska (1962, 1980) reports that in Poland the isophens for hazel follow the pattern of the January and February isotherms and the dates of the beginning of flowering differ in space and time. In early spring, when hazel and alder bloom, the weather is usually very changeable and temperature varies in the same season and between years. This is responsible for the fact that flowering dates of hazel and alders are more changeable than those of birch (Table 1). In 1999, the mean temperature of the first and second decade of February was below 0°C (Dekadowy Biuletyn Agrometeorologiczny 1999–2001), thus flowering of *Corylus avellana* and *Alnus incana* began later than in the other years (Table 1, Figures 1, 2). The large variation in hazel flowering dates is confirmed by Rizzi Longo and Pizzulin Sauli (1998). The temperatures preceeding the birch pollen season were similar in 2000 and 2001 (Dekadowy Biuletyn Agrometeorologiczny 1999–2001), which was probably responsible for small differences in flowering dates for this species (Table 1).

According to the literature data, *Alnus incana* flowers first and *A. glutinosa* follows about two weeks later (Białobok 1980). Such a flowering sequence occurred in 2000 and 2001. In the first year of observations, 1999, both species flowered at the same time, probably due to untypical weather (Figure 2). Low

temperatures persisted for a long time then suddenly rose at the beginning of March, which induced intense flowering of both species (Dekadowy Biuletyn Agrometeorologiczny 1999–2001).

The results of aeropalynological studies are a function of the phenological ones. Similarly to the phenological phases, the dates of pollen seasons are most varied for *Corylus* and *Alnus* (Table 1). According to Szczepanek (1994), the pollen seasons of *Corylus*, *Alnus* and *Betula* can start even with a two-month delay. Other characteristics of the pollen seasons which change from year to year are SPI and MPA values. Their values for *Betula* were most varied, whereas for *Corylus* they were very similar (Table 1). This must be the result of the local vegetation composition and cyclical production of pollen. Similar results were obtained by Spieksma et al. (1995), and Szczepanek (1994). After three years of study we can conclude that the hazel flowering period is shorter than the period when its pollen is present in the air (Figure 4). A similar relationship was observed for other taxa as well Lattore (1997, 1999) and Lorenzoni et al. (1998). Whereas it is surprising that for *Betula* the pollen season is shorter than its flowering time (Table 1, Figures 3, 4), despite the fact that birch pollen grains can float in the air for a long time and can be transported for long distances (Szczepanek 1994). Such results may be caused by both the method of estimating the pollen season (90%) and the course of seasonal curves.

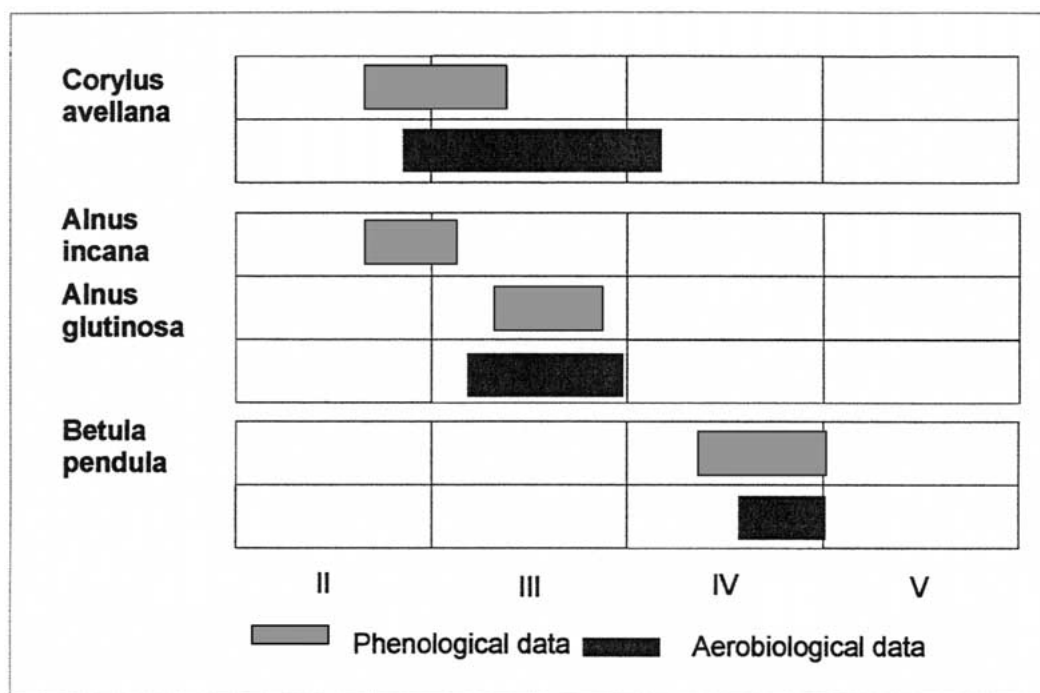


Figure 4. Phenological and aerobiological calendar of Rzeszów (average data).

For birch, in both years the maxima of both phenomena occurred at the same time (Figures 3, 4). First the flowering of birch was observed, then its pollen appeared in the air. Similar results were achieved by Jato et al. (2002) and Lattore (1997, 1999). Biological traits of the species must be partially responsible for these results. Birches produce pollen intensively for two weeks, but for the first two to three days 80% of pollen falls off the inflorescences (Białobok 1979). Weather must have influenced the results as well. In both years, the weather was stable at the time of flowering (Dekadowy Biuletyn Agrometeorologiczny 1999–2001), and birches probably started flowering at the same time over a vast area of land. The occurrence of *Betula* airborne pollen grains long after the pollen season is often recorded, and is explained by the effect of secondary fall and long transport (Szczepanek 1994).

For *Alnus*, in the two first years of study the maxima of each phenomenon did not occur at the same time (Figure 2). However the largest delay of pollen occurrence after flowering was recorded for *Corylus*. In none of the three years of study did the maximum pollen production time correspond to the maximum pollen occurrence time. For the first two years, the maximum density of pollen in the air was recorded

when hazel did not produce pollen in Rzeszów at all (Figure 1).

Pollen grains of alder and hazel outside the flowering period were recorded in large or even very large quantities (Figures 1, 2), which excludes a secondary fall. Thus it must be concluded that transport is responsible for this phenomenon (Comtois 1997; van de Water and Levetin 2001). Statistical analysis showed that in 1999 there was a significant relationship between the number of alder and hazel pollen grains and the direction of wind. Therefore we can assume that sources of pollen were located south of Rzeszów for hazel, and south and west from Rzeszów for alder. South of Rzeszów the climate acquires a more mountainous character, mean temperatures are lower and flowering dates are later. For instance, Sokołowska (1962) reports a ten day delay in the flowering of hazel in comparison of Rzeszów area. Numerous authors emphasise the relationship between the plant's flowering time and climate and altitude (Jato et al. 2002; Zanotti and Puppi 2000).

Gniazdowski and Klimas (1976) stress that the simultaneous analysis of phenological spectra and palynological and meteorological data gives a chance for more efficient pollen count warnings. In Rzeszów

phenological studies can be very helpful in preparing pollen prognoses for birch. It must be stressed that such observations can be made by people who suffer from allergies themselves, especially as birch is easily recognisable and is a source of strong allergens.

5. Conclusion

Hazel and alder flower at the beginning of the growth season when the weather is very unstable and this is responsible for the fact that the pollen seasons and flowering seasons of these taxa were very changeable in the study. In 1999, the maximum densities of hazel and alder pollen were recorded after the flowering period, as pollen was transported from elsewhere (hazel from south, alder from south and west). Pollen and flowering seasons of birch *Betula pendula* occur at the same time, hence for this species phenological observations can have practical role in allergology.

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