

Airborne pollen of entomophilous plants and spores of pteridophytes in Rzeszów and its environs (SE Poland)

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Abstract

Airborne pollen of entomophilous plants occurred in low or very low concentrations, and constituted 4% of the total pollen sum. In 1997–2002, between 18 and 26 taxa were identified. Out of this large group the following taxa were represented in larger concentrations every year: *Salix*, *Acer*, *Morus*, Cichorioideae, Asteroideae, *Plantago major/media*, *Sambucus nigra* and *Tilia*. Microscopic examination revealed that pollen grains of the above mentioned species were often glued together, which is a typical adaptation to this kind of pollination. Club moss (*Lycopodium* spp.) and horsetail (*Equisetum* spp.) spores were recorded sporadically. Fern spores were found frequently but in very low numbers. In 2002 the occurrence of the airborne pollen of entomophilous plants in the city and in the countryside was compared. A higher percentage value of pollen was found in the atmosphere of the city rather than in the countryside, due to the high concentration of *Acer* pollen, which is a partly entomophilous species and common in municipal plantings. In the countryside air there was a higher concentration of pollen from purely entomophilous species, such as *Viburnum* and Asteroideae.

1. Introduction

Airborne pollen usually comes from anemophilous plants (Dyakowska, 1959). This kind of pollen has many adaptations to free dispersal. It is produced in large quantities, is light, dry, smooth or with reduced ornamentation (Faegri and van der Pijl, 1979), there is little pollenkit on its surface (Hesse, 1981). Entomophilous plants on the other hand produce much less pollen. Pollen grains have rich ornaments (Faegri and van der Pijl, 1979) and they are covered by pollenkit or viscin threads. Owing to this they become glued together and attach to an insect visiting the flower (Hesse, 1981, 2000). These features cause the pollen of entomophilous plants to be noted usually in low concentrations, or sporadically, and the taxonomic composition of this group of plants does not exactly representative of the local flora. However many plants pollinated by insects are characterised by features typical of

anemophilous species, and species and even genera are known which are pollinated by insects and wind alike, e.g. *Plantago major*, *Salix* spp. (Faegri and van der Pijl, 1979; Proctor et al., 1996; Hesse, 2000). Entomophilous plants can also produce an enormous number of grains e.g. *Tilia cordata* and *Acer pseudoplatanus*, which remain airborne for a long time e.g. *Salix caprea* (Dyakowska, 1959; Faegri and van der Pijl, 1979), hence the pollen from entomophilous plants is a constant and important airborne element (Szczepanek, 1994; Kasprzyk, 1996, 1999). Pteridophyte spores are more rarely airborne (Edmonds, 1979). Little data on the subject of their appearance in the air has been gathered in the aerobiological literature. Recently their potentially toxic and carcinogenic effects on humans have been stressed (Lacey and McCartney, 1994; Caulton et al., 2000).

Podkarpacie (south-east Poland) is situated between two geobotanical regions: to the north

lowland Kotlina Sandomierska and to the south Carpathians. This situation has an essential influence on climate and vegetation. The climate of this region has a transitional character, between a lowland-foothill and a mountain climate. The mean annual temperature is 8.8 °C and mean annual precipitation 734 mm. The vegetation growth period lasts here from 215 to 222 days. In the northern part of this region dry-ground forests and coniferous forests occur; in southern part forests with beech and fir.

The aim of this work was to record the occurrence of the pollen grains of entomophilous, or partly entomophilous plants, and pteridophyte spores in the atmosphere of the town of Rzeszów on the basis of a 6-year-long study period. Analysis of the results was aimed towards ascertaining to what extent the pollen of these plants is an important component of aeroplankton, and the discovery of which taxa appear only sporadically and which in significant concentrations. The contents of airborne pollen is dependent upon the flora and vegetation in the area and the means of managing the land, which is why in 2002 aerobiological studies were undertaken both in an urban area (Rzeszów) and in a rural area. Comparison of the results of these two study sites had as their aim to verify whether or not there are more taxa of entomophilous plants noted in the air in rural areas, and the concentration of pollen of these plants is higher than in urban areas.

2. Materials and methods

The study was carried out in two study sites: in an urban area (Rzeszów) and on agricultural land (Krasne). The centre of the town lies 200–215 m above sea level. Flora and vegetation finds itself under significant pressure from human intervention, most plant communities have an anthropogenic character. The type of vegetation typical of parks dominates the landscape, vegetation is concentrated on urban lawns, and in domestic and roadside gardens. Krasne is a village with a typical landscape for the Podkarpacie region. Its characteristic feature is a lack of large areas of monoculture, cultivated fields cover only a few hectares each and next to them are buildings with gardens. Sampling of airborne pollen grains were carried out using the constant volumetric method from

1997 to 2002 in Rzeszów and in Krasne in 2002. Pollen traps (Burkard, Lanzoni) were left at the same height – approximately 12 m: the traps did not stand directly on the surface of the roof, but on stands, approximately 1 m high. A microscope slide was prepared each day, from which 12 vertical strips were analysed, magnified 400 times. Each strip corresponded to a 2 h interval (Emberlin et al., 1994). Count results were expressed as the number of pollen grains per cubic metre of air per 24 h. All the pollen grains and pteridophyte spores appearing on the slide were identified. Identification was carried out to the level of species (e.g. *Sambucus nigra*), genus (e.g. *Salix*), family (e.g. Apiaceae) or type (e.g. *Plantago major/media*). Unidentified pollen grains were counted as members of the group *Varia*. The above discussed group included entomophilous taxa as well as those pollinated by insects and wind (*Acer*, *Salix*, *Plantago major/media*) and self-pollinating taxa (*Triticum*) (Dyakowska, 1959; Faegri and van der Pijl, 1979; Proctor et al., 1996). In the pteridophyte group *Equisetum*, *Lycopodium* and Polypodiaceae were identified.

An annual total sum of pollen grains (SPI) was determined for each taxon, the percentage contribution to the overall annual total (in Table 1 values below 0.1% are not given), and for a chosen 8 taxa, a calendar of their occurrences in the air was determined (Figure 1). Statistical analysis of the results achieved was then carried out. The *u* test was used to determine whether or not the percentage values of entomophilous pollen grains and the 8 chosen taxa of these plants in the annual total, differed significantly between the study areas in 2002 ($\alpha \leq 0.05$).

3. Results

Over the 6 year period in 1 year, 18–26 taxa were identified belonging to the entomophilous group, and 2–3 types of pteridophyte spores. Most pollen taxa appeared every year, except for *Cornus*, which appeared only in 1998, Malvaceae in 1999 and *Sambucus racemosa* in 2002. The percentage value of this group of pollen in the annual total was not large and consisted of, on average, 4%. The pollen grains of most taxa occurred sporadically in the atmosphere, their SPI and percentage values were very low. The group of taxa whose pollen

Table 1. Annual sums (SPI) and percentage values of entomophilous taxa in 1997–2002 in Rzeszów and in 2002 in Krasne (*taxa pollinated by insects and wind)

Taxon	1997 Rzeszów		1998 Rzeszów		1999 Rzeszów		2000 Rzeszów		2001 Rzeszów		2002 Rzeszów		2002 Krasne	
	SPI	%	SPI	%	SPI	%	SPI	%	SPI	%	SPI	%	SPI	%
<i>Acer*</i>	13	0.1	56	0.2	501	1.4	207	0.6			321	1	13	
<i>Aesculus</i>	17	0.1	11		11		7		6		8		8	
Apiaceae	31	0.1	34	0.1	47	0.1	52	0.1	40	0.1	24	0.1	60	0.1
Asteriodeae	19	0.1	53	0.1	75	0.2	65	0.2	37	0.1	63	0.2	135	0.3
Brassicaceae	10		24	0.1	57	0.2	30	0.1	3		4		13	
Caryophyllaceae			8		3		2		2		1		11	
<i>Centaurea c.</i>									2					
Cichorioideae	6		14	0.1	24	0.1	19	0.1	11	0.1	13		21	0.1
<i>Cornus</i>			1											
<i>Erica</i>											1		2	
<i>Fagopyrum</i>									1		3			
<i>Filipendula</i>			23	0.1			24	0.1	8		5		44	0.1
<i>Frangula</i>					1		1		1					
<i>Impatiens</i>					4		3		6		5		4	
Lamiaceae					2		1		3		10		20	0.1
Malvaceae					2									
<i>Morus</i>	24	0.1	16	0.1	26	0.1	36	0.1	29	0.1	22	0.1	46	0.1
Oleaceae	3		6		2		3		5		1		2	
Papilionaceae	3		2		1		1		2		4		5	
Plantago m/m*	201	1	376	1.4	285	0.8	123	0.3	105	0.3	116	0.4	128	0.3
Polygonaceae													1	
Ranunculaceae	11	0.1	5		14		16		9		12		29	0.1
Rhamnaceae							1		1		1		2	
Rosaceae	15	0.1	57	0.2	46	0.1	15		24	0.1	24	0.1	27	0.1
Rubiaceae	3		11		8		7		6		8		8	
<i>Salix*</i>	111	0.5	258	1.1	917	2.5	603	1.6	361	1.4	557	1.8	433	1.1
<i>Sambucus n.</i>	49	0.2	28	0.2	93	0.3	131	0.3	136	0.4	62	0.2	85	0.2
<i>Sambucus r.</i>											32	0.1		
<i>Tilia</i>	51	0.2	135	0.5	56	0.2	93	0.2	39	0.1	35	0.1	13	
<i>Triticum</i>	90	0.4			7		18		7		5		10	
<i>Viburnum</i>	23	0.1	4		20	0.1	17		30	0.1	18	0.1	56	0.1
<i>Equisetum</i>														
<i>Lycopodium</i>	1		2		6		28	0.1	13		21	0.1	20	0.1
Polypodiaceae	9		39	0.1	18		4		2		7		1	
					59	0.2	82	0.2	33	0.1	30	0.1	37	0.1

Centaurea c. = *Centaurea cyanus*; *Plantago m/m* = *Plantago major/medica*; *Sambucus n.* = *Sambucus nigra*; *Sambucus r.* = *Sambucus racemosa*.

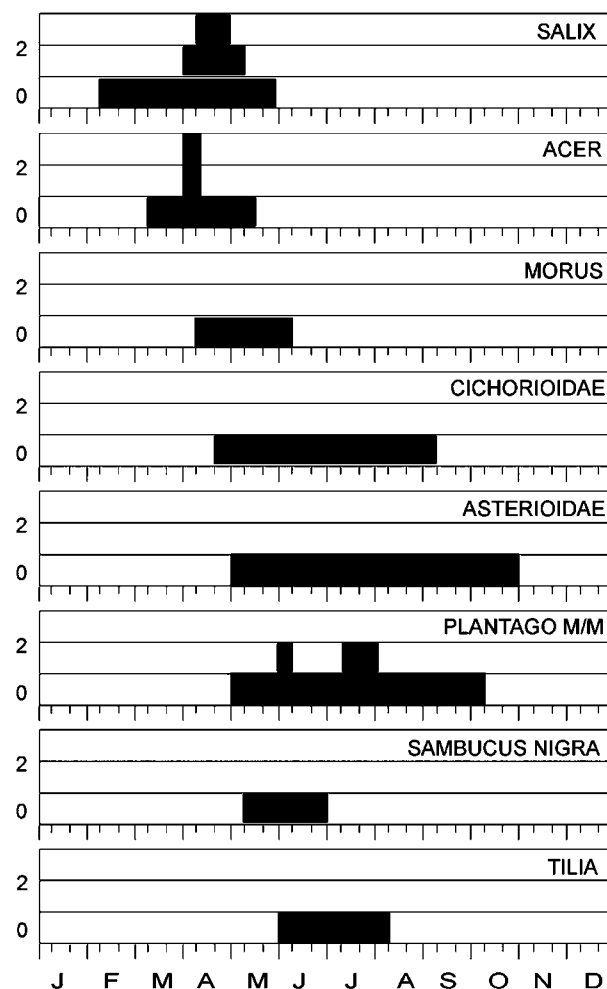


Figure 1. Pollen calendar for chosen entomophilous taxa for Rzeszów (range 1–3 correspond to average pollen concentrations: 0–5, 5–10, > 10 p/m³).

consistently appeared in relatively high concentrations included *Acer*, *Asterioideae*, *Cichorioideae*, *Morus*, *Plantago major/media*, *Sambucus nigra*, *Salix* and *Tilia*. Horsetail and club moss spores appeared in the air very rarely; however the SPI and percentage contribution values of *Polyodiaceae* were higher (Table 1). Figure 1 presents the seasonal variation of airborne pollen for the 8 chosen taxa of the above-mentioned group. With the exception of *Acer*, *Salix* and *Plantago major/media* the pollen concentrations were low. The length of pollen seasons in the air varied considerably from 1.5 months (*Sambucus nigra*) to 6 months (*Asterioideae*).

In 2002 analysis was carried out in two locations: in urban and rural areas. The number of

identified taxa was the same and the taxonomical composition did not considerably differ between study areas, e.g. only in the urban area was *Sambucus racemosa* and *Fagopyrum* pollen noted (Table 1). In the urban area pollen grains from the above mentioned group constituted 4.3% of the annual total and in the second study area 3%. It was noted that these values differ significantly ($\alpha \leq 0.001$).

The SPI values of taxa pollinated only by insects were generally higher in rural areas (*Asterioideae*, *Cichorioideae*, *Ranunculaceae* and *Filipendula*) and those pollinated equally by insects and wind (*Acer*, *Salix*) higher in the urban area (Table 1). In a few cases a significant statistical difference was noted in percentage contributions –

these values for *Morus*, Asteroideae were higher in the rural area and *Acer*, *Tilia*, *Salix* in the urban area ($\alpha \leq 0.05$). No significant difference was noted in percentage values and SPI in the case of pteridophyte spores between locations that differed in means of land use.

4. Discussion

Szczepanek (1994) produced a pollen calendar for the city of Krakow and distinguished between entomophilous taxa, whose pollen is regularly airborne and in considerably concentrations, and taxa whose pollen occurred sporadically. The list of these taxa is to a high degree consistent with the data shown in Table 1 and Figure 1. Despite the fact that the list of taxa from the above-mentioned group was relatively long, the achieved concentrations of pollen were low. Very often only a few pollen grains were noted in a year. Entomophilous plants are mostly green plants and pollen from this group of plants have more difficulty reaching the higher layers of the atmosphere, since it is emitted at a relatively low level in which turbulence has little significance (Faegri and Iversen, 1978). Pollen traps are usually set up at a height of several metres, where, as a few studies have shown, the concentration of the pollen of green plants is lower than at the height of the plants at near ground level (Hart et al., 1994; Latałowa and Góra, 1996).

The taxonomical composition of the above mentioned group does not differ considerably each year. Eighteen to twenty six taxa were identified annually, although only 8 of them were characterised by a clearly defined pollen season (Figure 1) and these were most commonly noted in the air in this climate zone (Szczepanek, 1994; Kasprzyk, 1996; Latałowa and Góra, 1996). The pollen of some of these plants appeared in the air for a relatively short time (*Morus*, *Sambucus nigra*), others, however, appeared for very long periods (Asteroideae, *Plantago major/media*; Figure 1). Taxa included in families or genera represented by many species (Asteroideae, Cichorioideae), do not always flower at the same time, hence their pollen grains are characterised by their long or very long pollen seasons (Szczepanek, 1994). Willows (*Salix* spp.), for example, appear in almost all habitats: dry and wet, on river banks and in green urban areas, and bloom from February (*Salix*

caprea, *S. cinerea*) to May (*S. alba*, *fragilis*), hence their pollen is airborne for a long period.

During the analysis of microscope slides it was observed that some types of grain appeared in groups (from 2 to several). They were above all, *Salix* pollen grains, but also Apiaceae, Ranunculaceae, Asteroideae, *Acer*, *Aesculus*, *Filipendula*, *Impatiens*, *Sambucus nigra*, *Tilia*, *Viburnum*, and Rosaceae. Entomophilous pollen grains have significantly more of pollenkitt than anemophilous ones. This substance and the richly textured grain cause them to join into pollen aggregates, which hinders their emission from the already opened anthers (Dyakowska, 1959; Faegri and Iversen, 1978; Hesse, 2000) and pollen grains often appear in the air in groups.

It seems that the means of using the land and the type of vegetation does not have a strong influence on the taxonomic spectrum. In 2002 in the urban and rural air, similar taxa were noted from the above-mentioned group (Table 1). Despite our hypothesis, the percentage contribution of pollen of entomophilous plants in the annual total was statistically significantly larger in the urban area ($\alpha \leq 0.001$). The relatively high frequency of pollen grains *Acer* and *Salix* in Rzeszów influenced these results. These taxa are partly entomophilous (Proctor et al., 1996) and considerably more frequently encountered in the urban flora, in parks and on roadsides, e.g. the anemophilous *Acer negundo*. The concentrations and percentage contributions of pollen grains that are only entomophilous were significantly larger in the rural area (Table 1). The area surrounding the second measurement point includes meadows containing buttercups (*Ranunculus* spp.), meadow sweet (*Fili pendula ulmaria*) and various members of the families Asteroideae, Apiaceae and Brassicaceae. The results confirm the thesis that the height of concentration of pollen in the air is dependent, amongst other things, on the flora and vegetation in the surrounding area (Hyde, 1959; Kasprzyk, 1999).

Pteridophyte spores are rarely identified in aerobiological studies and this is why they are reported sporadically. They are produced in great numbers, although they are big and heavy and reach the higher levels of the atmosphere with difficulty. Ferns and club mosses usually appear in the herb layer of forests, and the tree canopy does not allow their spores to travel freely. Club moss

not allow their spores to travel freely. Club moss spores appear in the air the most rarely, these plants appear in local forests and all the species are protected. In April, in general horsetail spores were recorded, sometimes the same elaters appeared on the microscope slides. They were probably *Equisetum arvense* spores, a cosmopolitan species which produces cones during this period. In August and September fern spores were regularly recorded in the air and their annual total was relatively high (Table 1). In England, Lacey and McCartney (1994) and Caulton et al. (2000) recorded a significantly higher concentration of *Pteridium aquilinum* spores, and stated that weather conditions also have a significant influence on levels of concentration.

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