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# *Preliminary results of pollen trapping in the region of the Roztocze National Park (SE Poland)*

Wstępne wyniki badań opadu pyłku roślinnego w rejonie Roztoczańskiego Parku Narodowego (Polska SE)

## INTRODUCTION

Monitoring of modern pollen deposition in the region of the Roztocze National Park is a part of the Pollen Monitoring Programme (PMP). This international project, initiated in 1996 by a group of palynologists from 15 European countries under the direction of Sheila Hicks (University of Oulu, Finland), aims at studying pollen deposition of different tree species and other plant groups, which are important for palynological interpretations, in approximately natural conditions, i.e. in national parks and reserves. The introduction to the PMP guidelines describes the scientific background of the project in detail (Hicks et al. 1996). The areas in which tree species reach their modern limits of dense occurrence are especially interesting. PMP acts as a working group within the Holocene Subcommission of INQUA (International Union for Quaternary Research). Computer processed results of monitoring are sent to the database in the University of Oulu once a year. Long term data concerning pollen deposition in different areas give information necessary for past vegetation and palaeoecological reconstructions of the Quaternary, correlation of the Quaternary plant communities in large areas, and other interpretation not only of palaeobotanical– but of palaeoecological and phenological-climatic use as well.

Pollen analysis, being the main method for past vegetation reconstructions, needs nowadays modern tools to solve complex problems concerning, not only the detailed relationships between pollen deposition and vegetation, but investigating past forest limits, tracing the special presence of single species at different points of time or estimating source area of pollen and pollen productivity as well (Broström 2002; Hicks, Hyvärinen 1999; Hjelle 1998, 2000). Since an objective basis for such pollen analytical interpretations is still lacking, the method used by the PMP group concentrates on building up a great body of data and comparing the results obtained by different authors in different regions (Hicks et al. 1996). This can be achieved by calculating pollen deposition of the major tree species and the ecologically significant shrub and herb species of Europe using *pollen influx* (PI) values (number of pollen grains deposited in an area unit during a given time, usually grains/$cm^2$/year) rather than calculating percentages (Davis 1976, Davis et al. 1980, Hicks et al. 1996). Such a palynological tool is essential when quantifying past plant cover. This purpose was a guiding principle for the authors of the Pollen Monitoring Programme, which started as the European Pollen Monitoring Programme (Hicks et al. 1996). The name Pollen Monitoring Programme was introduced when extra-European countries joined the project. The scientists engaged in the PMP present the latest results of their studies and exchange opinions during international meetings. Instructions for palynologists belong to the most important results of these meetings (Hicks et al. 1999). The fourth meeting was held at the Maria Curie-Skłodowska University in September 2002.

This article summarizes the preliminary results of pollen monitoring in the region of the Roztocze National Park situated in the south-eastern Poland.

The whole region of the Roztocze is especially interesting for this type of study because multispecies forests cover its large areas. The Roztocze has individual physiographic features compared with surrounding regions. It forms a distinct elevation in south-eastern Poland and extends towards the Ukraine beyond Lvov. The region is ca. 180 km long (110 km belongs to Poland) and 15–28 km wide. Due to the diversified relief and vegetation it can be divided into several parts from which the central one is called the Middle or the Tomaszów Roztocze (Chałubińska, Wilgat 1954; Maruszczak 1972; Buraczyński 1997). The Roztocze National Park is situated in the Middle Roztocze (Fig. 1). The hills here are up to 350 m high and are composed of Upper Cretaceous rocks: opokas, marly opokas and gaizes. Twice during the Quaternary the Roztocze region was under the influence of the ice sheet (Harasimiuk 1994). The Quaternary deposits cover summits and slopes with a thin layer but in valleys their thickness reaches several tens of meters. The Roztocze, with the mean annual temperature of 7°C, is somewhat cooler region than the surrounding lower lying areas (Warakomski 1994). It is also more wet. The mean annual precipitation about 710 mm is 110 mm higher than the average value for Poland (Kaszewski et al. 1995, 2002; Warakomski 1994). Snow cover persists for ca. 80 days, i.e. 22 days longer than the average value for Poland.

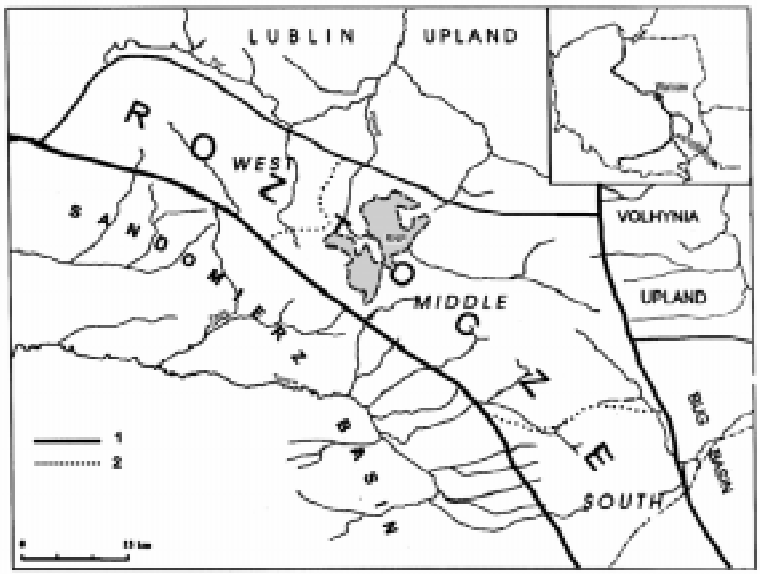


Fig. 1. Location of the area under investigation; 1 – macroregion boundary, 2 – mesoregion boundary, RNP – Roztocze National Park
Położenie obszaru badań; 1 – granice makroregionów, 2 – granice mezoregionów, RNP – Roztoczański Park Narodowy

About 60% of the Roztocze forests are up till now of the natural, original character. One can learn about the post-glacial vegetational changes in the Middle Roztocze from the results of palynological studies by Bałaga (1998). The diversified relief and soil conditions cause the zonal distribution of forest communities. Nowadays nineteen different forest associations have been distinguished here of which the most precious are fir tree-woods (*Abietetum polonicum*) and Carpathian beech forests (*Dentario-glandulosae-Fagetum*). *Abietetum polonicum* covers down and middle parts of the hill slopes while *Dentario glandulosae-Fagetum* – the summits of the hills (Izdebski et al. 1992; Izdebski 2002). Both forest types are characteristic of the lower subalpine forests of the Carpathian mountains. Beech forests and fir woodlands are also of special interest for the present study. In the river and stream valleys there occur alder carrs and alder swamps. They are usually surrounded by a narrow belt of wet oak-spruce woods. Different pine forests occur on plains and dunes (Izdebski et al. 1992; Izdebski 2002). Meadow communities form the greatest complexes in the Wieprz river valley.

In the Roztocze several tree species, important in the European scale (first of all beech and fir, but also sycamore, spruce and latifolious lime), reach the north-eastern limit of their continuous extent (Izdebski et al. 1992). The regional climate of the Roztocze is particularly favourable for trees demanding suitable moisture of air and soil, i.e. *Fagus sylvatica* and *Abies alba*. Despite their occurrence near the limits of distribution, beech and fir trees reach monumental size. The most natural parts of the forests are protected within the Roztocze National Park.

Pollen monitoring according to the PMP rules (Hicks et al. 1996) has been realized in the Roztocze by means of nine pollen traps kept in the ground the whole year round. The present study comprises the results from the years 1998–2001.

## MATERIAL AND METHODS

### THE STUDY AREA

The nine sites for pollen monitoring were chosen in the Roztocze National Park itself and within its surroundings in the Guciów village (Fig. 2). The University of Maria Curie-Skłodowska possesses the field station – the Roztocze Research Station in Guciów, which provides basis for our pollen study and different kinds of field research, studies on the regional vegetation among them (Grądziel, Janicki 2002).

Pollen traps were placed in the following plant communities (Fig. 2).

Trap no 1 was placed in the fir tree woodland /*Abietetum polonicum*/ overgrowing higher terrace (altitude 247 m a.s.l.) in the valley bottom of the Wieprz river. Fir trees (*Abies alba*) cover 95% within a 100 m radius around the trap, 5% is covered by beech (*Fagus sylvatica*). The minimum distance of trees is 8 m. Although such a distance seems rather small, it is impossible to find any clearance of a bigger radius within fir woods, which are generally very dense and dark.

The second trap was placed in the opening of the mixed forest consisting of *Pinus sylvestris* (70%) and small (ca. 25%) admixture of *Betula pendula*, *Quercus robur*, *Fagus sylvatica* and *Carpinus betulus*. *Sorbus aucuparia*, *Frangula alnus* and different *Salix* species appear sporadically. The forest overgrows the higher terrace (altitude 247 m a.s.l.) in the Wieprz valley bottom to the west of the trap no 1. The minimum distance of pine and birch trees is 15 m, of beech, hornbeam and alder – 20 m, while this of oak and spruce – 25 m.

Trap no 3 was placed in the NE foot of the slope (altitude 247 m a.s.l.). This is a transitional zone close to the forest edge. The main components of this forest are *Pinus sylvestris* (40%) and *Abies alba* (50%). Beech, hornbeam, ash, larch, poplar, elm and lime trees appear as an admixture. There are single specimens of *Corylus avellana*, *Crategus* sp. and *Rubus* sp. The minimum distance of pine, fir, beech, lime and hornbeam trees is 25 m and of ash tree – 27 m. There are also 4 elm trees (ca. 60 m) a dozen or so *Corylus* shrubs cultivated up the slope.

Fig. 2. Location of pollen traps against the aerial photo of the Guciów village surroundings
Rozmieszczenie pułapek pyłkowych na tle zdjęcia lotniczego okolic wsi Guciów

Trap no 4 was placed in the middle of the large clearing, where there are two cultivated fields within the mixed forest (altitude 247 m a.s.l.). The trap is at the eastern foot of the slope in the valley bottom. The dominant components of the forest are pine and birch in similar percentages (40% each). Other tree species (*Abies alba*, *Fraxinus excelsior*, *Quercus robur, Picea abies*, *Populus tremula*, *Alnus glutinosa* and *Carpinus betulus*) stand for the rest of 20%. The minimum distance of all trees is 40–50 m.

Trap no 5 was placed at the forest edge at the top of the northern slope (altitude 279 m a.s.l.). The hill top is overgrown with beech forest (beech trees – 80%) with 10% admixture of hornbeam and 10% for other trees (*Pinus sylvestris*, *Populus tremula*, *Acer pseudoplatanus*, *Abies alba*, *Tilia cordata*). *Frangula alnus*, *Evonymus europaeus, Salix aurita*, *Salix caprea* and *Prunus spinosa* appear in the understorey at the forest edge. The minimum distance of beech and hornbeam trees is 2 m, of all other trees – ca. 80 m.

Traps no 6 and no 7 are intended to be regional ones. Trap no 6 was placed on the hilltop within cultivated and abandoned fields. No trees are present within a 30 m radius around the trap. The hill is the highest point of the area (altitude 305 m a.s.l.).

Trap no 7 was placed at the eastern foot of the slope (altitude 246 m a.s.l.) near the Roztocze Research Station in Gučiów. Within the 100 m radius around the trap there dominate *Betula pendula* trees (50%) the other half is composed of *Pinus sylvestris* trees with a small admixture of *Populus tremula* ones and *Salix caprea* and *Salix aurita* shrubs. The minimum distance of birch, pine and willow specimens is 12 m.

Trap no 8 was placed at the flat-topped hill (altitude 348 m a.s.l.) in the middle of the large clearing within the beech forest. At a distance of 70 m from the trap there are birch, beech hornbeam, poplar and pine trees as well as willow shrubs and *Rubus* spp. bushes. In the first year of monitoring there existed cultivated fields with cereals, rape and buckwheat in the middle of the clearing but in subsequent years the fields were abandoned. The minimum distance of all trees is ca. 70–80 m.

Trap no 9 was placed at the altitude of 355 m a.s.l in the small clearing near the beech forest edge on the flat-topped hill. The minimum distance of beech and sycamore specimens is 8 m and of hornbeam and birch ones – 50 m.

As shown in Figure 2, the two traps (nr 6 and 7), which are intended to be regional, are situated in the central part of the study area so that several transects can be formed leading from forests (traps 1, 2, 4, 8, 9) through forest edges (traps 3, 5) to more open situations (traps 6, 7) according to PMP guidelines (Hicks et al. 1996). The size of the forest openings differs very much and the distance of single tree species to the trap is different as well. This offers various possibilities to trace pollen influx of single tree species in different situations.

POLLEN TRAPS

A modified Tauber-style pollen trap (Hicks, Hyvärinen 1986; Hicks et al. 1996) used for the present studies is a plastic 5 litres container with a 5 cm diameter hole according to PMP guidelines. The neck of the container is cut down so that its walls form a kind of a collar-like structure, which sheds rain (Fig. 3). A special modification, made after the first pollen season, is the coarse metal net that covers the hole to protect it from falling down of small rodents and big insects. Such a net was not recommended originally, since there is no need to cover the opening in tundra or boreal forests vegetation zones in the northern Scandinavia. However, it occurred to be useful and practical in warmer regions. During the first year of monitoring the contents of 6 traps was spoilt by decaying animal remains and subsequent fungal growth. The following year, consultations with PMP Advisory Board resulted in putting a net on the top of the 5 cm hole. Problems in the field with mice, frogs, insects were reported by some other investigators as well (Koff 2001; Van der Knaap et al. 2001; Noryśkiewicz A. – oral information). As a result the supplement to the PMP guidelines (Hicks et al. 1999) recommended stretching wires just above the trap or putting a net over the top of the trap in warmer climatic zones. Obviously such traps must be controlled

Fig. 3. Pollen trap used in the study
Pułapka pyłkowa stosowana w badaniach

more carefully to see whether there are no leaves that got stuck and block the trap opening and stop pollen deposition into it.

The bottom of the trap is covered with a mixture of glycerin, formalin and thymol in recommended quantities (Hicks et al. 1996).

### LABORATORY TREATMENT

Pollen traps are collected twice a year – in spring (March–April) after melting of the snow cover and in October. In spring the trap content is filtered immediately and the filter paper is frozen. This spring collecting of traps in the Roztocze is an additional one. It prevents not only the over-flooding of the traps (when there is a lot of water from melted snow) but fungal growth, due to diluted formaline, as well. In October, after the second collecting, the collected traps are subjected to the standard laboratory treatment (Hicks et al. 1996). The first step is sieving through a coarse sieve, followed by the addition of *Lycopodium* tablets (Stockmarr 1971), dissolved previously in distilled water, to the trap contents. Five *Lycopodium* tablets are always added, which is a maximum recommended quantity. After that, filtering through a filter paper and then acetolysis for 2 minutes follow. During the acetolysis the first frozen filter paper is added, which contains pollen material from late autumn and winter. Thus the sample pollen contents represents one year (including both the flowering and the non-flowering seasons). After acetolysis the pollen is stained with fuchsin and subjected to microscopic observations and counting. The results are presented in Table 1 and in Fig. 4.

Generally the sum was counted up to 1000 AP+NAP grains and approximately 100 *Lycopodium* spores encountered. Twice, due to over-burning during the acetolysis of the two samples (G6 and G9 in the year 2001), the achieved basic sum was lower with only 40–50 *Lycopodium* spores encountered. Thus the results might not be reliable.

## RESULTS AND DISCUSSION

The article concentrates on tree pollen influx since non-arboreal pollen values reflects, as usual, the very influence of the rich local vegetation. As far as herbal vegetation around the traps is concerned, the especially high values were noted for *Poaceae* (ranging from 10,000 to 45,000 grains/cm$^2$/year) and for sorrel that reached ca.10,000 to 18,000 grains/cm$^2$/year in some traps.

During the four years (1998–2001) the pollen influx values for the total sum of tree pollen (AP) ranged from ca. 6,000 to 22,000 grains/cm$^2$/year (Fig. 4). However, in the first sampling year (1998) the contents of only 3 traps (G3, G4, G6) survived and was not spoilt by decaying animals and subsequent fungal growth.

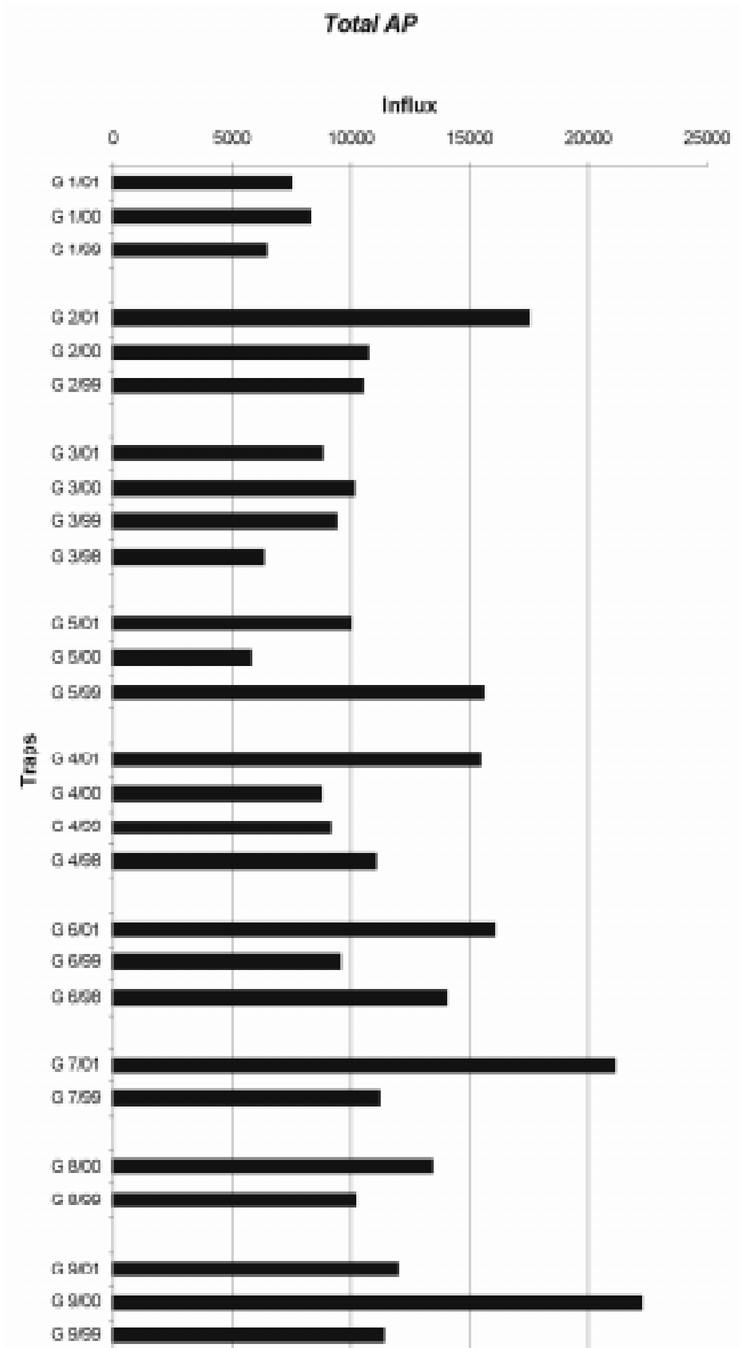


Fig. 4. Total pollen influx of trees in 1998–2001
Wartości wskaźnika pollen influx dla drzew w latach 1998–2001

For single tree species in the Roztocze the pollen influx (PI) varied remarkably in different years (Table 1).

Table 1. Pollen influx values of the main tree species of the Roztocze National Park in the years 1998–2001
Wartości *pollen influx* dla głównych gatunków drzew Roztoczańskiego Parku Narodowego w latach 1998–2001

| Site numer/ year | *Pinus sylvestris* | *Betula pendula* | *Alnus glutinosa* | *Abies alba* | *Carpinus betulus* | *Fagus sylvatica* | *Picea abies* |
|---|---|---|---|---|---|---|---|
| G 1/01 | 1867 | 2834 | 988 | 1208 | 307 | 109 | 0 |
| G 1/00 | 1708 | 1832 | 173 | 2204 | 148 | 1634 | 297 |
| G 1/99 | 2057 | 1260 | 362 | 869 | 521 | 550 | 57 |
| | | | | | | | |
| G 2/01 | 9671 | 5339 | 1334 | 163 | 408 | 27 | 163 |
| G 2/00 | 4332 | 3346 | 363 | 1063 | 467 | 181 | 337 |
| G 2/99 | 5968 | 1846 | 483 | 304 | 878 | 143 | 71 |
| | | | | | | | |
| G 3/01 | 1702 | 4086 | 1440 | 104 | 733 | 78 | 0 |
| G 3/00 | 3106 | 4251 | 712 | 101 | 178 | 509 | 127 |
| G 3/99 | 3317 | 2616 | 863 | 458 | 620 | 53 | 0 |
| G 3/98 | 2061 | 2333 | 2294 | 0 | 758 | 136 | 38 |
| | | | | | | | |
| G 5/01 | 1834 | 3398 | 2211 | 53 | 1861 | 134 | 26 |
| G 5/00 | 1602 | 2243 | 106 | 106 | 480 | 534 | 80 |
| G 5/99 | 2682 | 2308 | 603 | 436 | 8547 | 124 | 0 |
| | | | | | | | |
| G 4/01 | 5307 | 4391 | 3405 | 516 | 1291 | 23 | 46 |
| G 4/00 | 3143 | 3379 | 209 | 314 | 471 | 523 | 340 |
| G 4/99 | 4874 | 1577 | 675 | 266 | 1044 | 184 | 81 |
| G 4/98 | 3605 | 3046 | 3854 | 341 | 1958 | 528 | 93 |
| | | | | | | | |
| G 6/01 | 4518 | 7707 | 3189 | 132 | 132 | 265 | 0 |
| G 6/99 | 3822 | 3188 | 675 | 42 | 886 | 126 | 126 |
| G 6/98 | 3600 | 3715 | 6894 | 38 | 957 | 229 | 76 |
| | | | | | | | |
| G 7/01 | 7552 | 10276 | 1915 | 107 | 512 | 26 | 80 |
| G 7/99 | 4802 | 4177 | 706 | 60 | 605 | 100 | 20 |
| | | | | | | | |
| G 8/00 | 1949 | 4059 | 240 | 26 | 640 | 4887 | 106 |
| G 8/99 | 4391 | 2907 | 589 | 101 | 752 | 426 | 20 |
| | | | | | | | |
| G 9/01 | 5496 | 4014 | 2055 | 95 | 47 | 143 | 0 |
| G 9/00 | 4962 | 5367 | 755 | 0 | 215 | 9062 | 26 |
| G 9/99 | 4328 | 2876 | 1222 | 25 | 1247 | 534 | 50 |

In Table 1 – G stands for Guciów, nos 1, 2, …9 are the numbers of pollen sites and 98, 99, 00,01 mean 1998–2001 years respectively. The number of traps are arranged according to north-south direction where G1 is the most northern site, while G9 – the most southern one.

W tab. 1 – G oznacza Guciów, numery 1, 2…, 9 stanowią numerację stanowisk, natomiast 98, 99, 00, 01 oznaczają lata 1998–2001. Stanowiska w tab. 1 uszeregowane są od góry do dołu zgodnie z kierunkiem północ–południe, tak że G1 oznacza stanowisko wysunięte najdalej na północ, a G9 – najdalej na południe.

Below there are summarized the preliminary results concerning the main tree species of the Roztocze forests – *Abies alba*, *Fagus sylvatica*, *Pinus sylvestris*, *Betula pendula*, *Carpinus betulus*, *Picea abies* and *Alnus glutinosa*. The results are grouped into five groups representing quite similar types of vegetation communities, which show more or less similar trends in pollen influx values.

### SITE G1 – FIR WOODLAND

The PI values for *Abies alba* ranged from over 870 to 2,200 grains /cm$^2$/year with the maximum value in the 2000 year. Quite high were the values of *Fagus sylvatica* pollen (up to 1,600 in 2000 year) probably due to the presence of a mature beech tree at a distance of 8m from the trap. The PI of *Picea abies*, which is rather under-represented, seemed also quite high in 2000 (ca. 300 grains/cm$^2$/year) compared with the two neighbouring years in which PI did not reach 60. The PI values of *Alnus glutinosa* were the highest in 2001 (almost 1,000 grains/cm$^2$) as in all other traps in the same year (except for G8). Pine and birch values ranged from 1,260 to 2000 except for 2001 year when higher values of *Betula pendula* pollen were noted (ca. 2,800 grains/cm$^2$). Hornbeam's highest values were noted in 1999 (over 500 grains/cm$^2$).

### SITES G2 AND G4 – MIXED MULTISPECIES FORESTS

At both sites PI values for pine (almost 10,000 at G2 and 5,300 at G4), birch (ca. 5,300 and 4,400 respectively) and alder pollen (ca. 1,300 and 3,400 respectively) were the highest in 2001. However for hornbeam, it was in 1999, that at G2 its pollen reached the maximum of about 880 grains/cm$^2$, while at G4 its values were very high in three years 1998, 1999 and 2001 (ca. 2,000, 1,000 and 1,300 grains/cm$^2$/year respectively). On the other hand PI for *Abies alba* at G2 amounted to about 1,000 grains/cm$^2$ in 2000, which was only twice lower than in the *Abietetum polonicum* association. Fir values at G4 were ca. 300 grains /cm$^2$/year in the seasons 1998–2000, but in 2001 they reached about 500 grains/cm$^2$. The values of beech and spruce at both sites were the highest in 2000 year. For spruce PI reached ca. 340 grains/cm$^2$, while for beech – 180 grains/cm$^2$ at G2 and over 520 at G4. The same high PI values for beech (over 520 grains/cm$^2$) were noted in 1998 at G4 as well.

### SITES G3 AND G5 – EDGE OF THE MULTISPECIES FOREST

The results at both the sites are more or less similar but for the G3 site the results of the 4 monitoring seasons are available, while for G5 – of the 3 years only. Every year pine and birch predominated pollen spectra with the highest PI values for pine over 3,000 (G3 site in 1999 and 2000) and ca. 2,600 (G5 site in

1999). Birch reached over 4,000 grains/cm$^2$/year twice at G3 site (in 2000 and in 2001), while at G5 the maximum values were ca. 3,400 in 2001. The values of alder pollen showed two peaks at G3 site – in 1998 (ca. 2,300 grains/cm$^2$) and in 2001 (1,440 grains/cm$^2$). At G5 site, where the data for 1998 year are lacking, the maximum of over 2,200 grains/cm$^2$/year was noted in 2001. The PI for *Fagus* was the highest in 2000 at both sites (over 500 grains/cm$^2$), while those of *Abies* in 1999 (over 430 grains/cm$^2$ at both sites).

### SITES G6 AND G7 – CULTIVATED FIELDS

At both sites the PI values for 2000 year are lacking because someone emptied the traps, thus the whole year was lost. Pine and birch pollen predominated the spectra with the highest PI in 2001 – about 4,500 grains/cm$^2$ for *Pinus* at G6 site and 7,500 at G7, while for *Betula* the values were ca. 7,700 at G6 and 10,300 at G7. The third, in terms of abundance, was alder pollen with the high values also in 2001 (ca. 3,200 grains/cm$^2$ at G6 and 1,900 at G7). Besides the data from 1998, available at G6, showed the very abundant alder pollination as well (ca. 6,900 grains/cm$^2$). The PI values of beech were not very high – ca. 120–260 grains/cm$^2$/year at G6 and up to 100 at G7. For fir PI was even lower – ca. 40–130 at G6 and ca. 60–100 at G7. Hornbeam pollen was more abundant – ca. 880–950 grains/cm$^2$/year at G6 in 1998 and in 1999 and ca. 500–600 grains/cm$^2$/year at G7. *Picea* pollen reached its maximum in 1999 – over 120 grains/cm$^2$.

### SITES G8 AND G9 – BEECH FOREST

Extremely high PI for *Fagus*, the main component of pollen spectra, was achieved in 2000 (over 4,800 grains/cm$^2$ at G8 and 9,000 at G9). The second, in terms of abundance, component of pollen spectra was *Pinus* and *Betula* pollen. The PI values for pine were the highest at G9, ranging from over 4,300 to 5,500 grains/cm$^2$/year, while at G8 they achieved the same level (4,300 grains/cm$^2$/year) in 1999 but the half of this value in 2000. The PI for birch ranged from ca. 2,900 to over 5,000 grains/cm$^2$/year at both sites. It should be stressed however that the fields in the G8 site were under cultivation only in the first year of the monitoring (i.e. in 1998). In the following years they fields were abandoned and slowly overgrowing by birch, which is a general tendency in the Roztocze region caused by economic factors. Thus an increasing birch pollen deposition should be expected on this site in the next years. The values of *Abies* pollen were very low – did not exceed 100 grains/cm$^2$/year, and so did the PI for *Picea*. On the other hand PI for *Carpinus*, which seemed quite constant at G8 (640–750 grains/cm$^2$/year), got a very high peak of over 1,200 grains/cm$^2$ at G9 in 1999.

Great variation of PI values in pollen traps was noted also by all pollen monitoring participants (Hicks 2001; Hicks et al. 1996, 2001; Koff 2001, Kvavadze 2001; Tonkov et al. 2001; Van der Knaap et al. 2001 and other papers). The occurrence of high pollination years for different tree species is obvious for aerobiologists as well. However, not all the factors influencing this phenomenon have been known so far. Studies in the Alps (Van der Knaap et al. 2001) revealed that years of very high pollen influx follow years with high air temperatures from June to November of the previous year for *Larix*, *Picea* and *Pinus sylvestris*. However, for *Betula* and *Alnus viridis* such a correlation was not stated by them. Hicks (2001) found another correlation that seems to be between the average July temperature of the year prior to the year of abundant pine flowering. Undoubtedly climatic parameters (mean air temperature, wind strength and direction, snowfall, which were suggested to influence high deposition of pollen) should be taken into account when explaining these phenomena in the Roztocze but such a study needs much greater data set.

1998 was, in the Roztocze, the year of rather high pollen values of many tree taxa. This statement agrees with the results obtained in Finland by Hicks (2001) and in Estonia by Koff (2001). The last author noticed that the AP influx was up to 3 times higher than in 1997. She noted also the very high PI for *Picea* – up to 2,100 grains/cm$^2$ in 1998. The PI for the total tree pollen (AP) calculated by Koff (2001) in Estonian forests during two seasons 1997 and 1998, varied from 23,000 to 41,000 grains/cm$^2$/year. Thus the values from the Roztocze are somewhat lower.

In the 2000 year, according to the presented data for the Roztocze region, several tree species noted their high influx values. These were *Fagus sylvatica*, *Picea abies*, *Abies alba*, while other trees have their high values in 2001. These were *Alnus glutinosa*, *Betula pendula* and *Pinus sylvestris*.

The highest PI for *Fagus sylvatica* in 2000 achieved 9,000 grains/cm$^2$ in beech forest and the influx values were the highest in all traps as well. According to the Bulgarian results obtained by Tonkov et al. (2001) in the altitudinal belts of the Rila Mountains, there were two maxima for *Fagus sylvatica* – in 1994 (4,070 grains/cm$^2$) and in 1999 (3,780 grains/cm$^2$), with the intervening four years of low pollen production. Unfortunately no results were available directly from Bulgarian beech forest, since the pollen trap placed in this community had been stolen. These two peaks of high PI were probably connected with the cyclicity in abundant flowering known for beech and other trees of *Fagaceae* family (Tonkov et al. 2001). Nowadays, the data set for the Roztocze region is obviously too small to draw any conclusions concerning cyclicity.

The present study showed that the highest influx values of *Picea* pollen were noted in 2000 together with the highest values of *Fagus*. The same coincidence was observed in the Rila Mountains in Bulgaria in 1994 although for all other taxa it was a very low pollen year (Tonkov et al. 2001).

The high values of *Abies alba* pollen were noted in the Roztocze in 2000 in fir woodland (over 2,200 grains/cm$^2$) and at the G2 site (over 1,000 grains/cm$^2$), which is the nearest trap to the fir woodland. When compared to the results by Tonkov et al. (2001), which ranged from 600 to 700 grains/cm$^2$/year, the fir PI in the Roztocze seems to be quite high. However, taking into account that *Abies alba* occupies only 10% of the surrounding vegetation in the Rila Mountains, while in the Roztocze – much more, the values of several hundred grains for Bulgaria are quite considerable.

Unfortunately, in the Roztocze in 2000, no results from the so called regional traps (G6 and G7), placed on the hill tops, could have been obtained because the contents of these two traps were lost. Thus there is no reference material concerning the problem how do high *Fagus*, *Picea* and *Abies* influx values are reflected in the regional tree influx.

The results for *Alnus glutinosa*, *Betula pendula* and *Pinus sylvestris* seem to indicate that it was in 2001 that the production of their pollen was much higher. This was confirmed by aerobiological monitoring for alergological purposes in Lublin (a distance of 120 km from the area under investigation) and in Warsaw. According to these results (conducted in 2000–2001) the pollen count of alder in 2001 in both cities was 12–20 times higher than in 2000 (Weryszko-Chmielewska et al. 2001). The calculations for the *Betula* pollen were very similar. The birch tree pollen count in 2001 in Warsaw reached even 5,300 grains in m$^3$ per 24 hours, which was the highest value during the time of the observation (Weryszko-Chmielewska et al. 2001). The authors of the above-mentioned study consider these high birch pollen values to reflect the biannual flowering rhythm of *Betula*.

## CONCLUSIONS

In spite of quite a short time of monitoring some conclusions can be drawn.

The results reflect the variation of pollen deposition in different years, among which there were years of a high pollination, although these were not the same years for all tree species. In 2000 PI for beech, fir and spruce was very high while for alder, birch and pine it was in 2001 that their pollen production was much bigger.

There was also a great variation in PI values at different sites – in forest clearings (traps G2, 4, 8, 9), forest edge (G3, 5) and open vegetation (G6, 7). The last traps were of a regional character and gathered pollen from a wider area.

The PI values for the main tree species are obviously the highest in these forest communities in which the tree is abundant (beech forests or fir woodland) but also a single tree can deliver a significant number of pollen grains to the trap contents (as did the mature beech tree near the G1 trap).

Pollen production of beech, spruce and fir seems to be lower in the Roztocze than in the Rila Mountains in Bulgaria (Tonkov et al. 2001)

Pollen production of *Pinus sylvestris* in the Roztocze seems to be higher than in Fennoscandia (Hicks 2001) but lower than in Bulgaria (Tonkov et al. 2001), which agrees with the first records from the Pollen Monitoring Programme (PMP). According to Hicks et al. (2001) the general trend revealed after 4 years of monitoring showed that overall *Pinus* pollen influx increases with decreasing latitude in Europe.

The results of aerobiological monitoring of *Betula* and *Alnus* pollen, conducted by Weryszko-Chmielewska et al. (2001) in 2000–2001 in Lublin and Warsaw, agree with the results of the present study very well when peak year (2001) for *Betula* and *Alnus* pollen is compared.

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## STRESZCZENIE

Badania monitoringowe współczesnego opadu pyłku roślinnego na Roztoczu prowadzono w ramach międzynarodowego projektu Pollen Monitoring Programme (PMP), funkcjonującego jako grupa robocza w podkomisji holoceńskiej INQUA. Celem projektu jest określenie wielkości depozycji pyłku różnych gatunków drzew i innych grup roślin, ważnych z punktu widzenia interpretacji palinologicznych, w warunkach zbliżonych do naturalnych (parki narodowe, rezerwaty). Dziewięć standardowych całorocznych pułapek pyłkowych (ryc. 2) umieszczono w gruncie w różnych zbiorowiskach roślinnych w Roztoczańskim Parku Narodowym i jego otulinie (wieś Guciów). Dwie pułapki umieszczone były w terenie otwartym w celu wychwytywania opadu regionalnego. Aktualna praca koncentruje sie na obliczeniu wielkości *pollen influx* (ilość ziaren pyłku danego taksonu na $cm^2$ powierzchni na rok) dla głównych drzew Roztoczańskiego Parku Narodowego w latach 1998–2001. W omawianym okresie wskaźnik ten wynosił 6 tys.–22 tys. dla całkowitej sumy AP (ryc. 4) i wahał się znacznie w poszczególnych latach dla różnych gatunków drzew (tab. 1). W roku 2000 odnotowano obfite pylenie *Fagus sylvatica*, *Abies alba* i *Picea abies*, podczas gdy rok 2001 był szczególnie sprzyjający pod tym względem dla *Alnus glutinosa*, *Betula pendula* i *Pinus sylvestris*. Wyniki monitoringu pyłkowego drzew roztoczańskich porównano ze wstępnymi wynikami analogicznych badań prowadzonych w Finlandii, Estonii i Bułgarii w ramach PMP oraz danymi dotyczącymi pylenia *Alnus* i *Betula* w Lublinie w latach 2000–2001.