

**Comparison of pollen concentration of selected tree taxa in Lublin
and in the Roztocze region (SE Poland) – the results
of three monitoring methods**

**IRENA AGNIESZKA PIDEK¹,
ELŻBIETA WERYSZKO-CHMIELEWSKA²,
KRYSTYNA PIOTROWSKA²**

¹ Institute of the Earth Sciences, M. Curie Skłodowska University,
al. Krasnicka 2c/d, PL 20 718 Lublin

² Department of Botany, Agricultural University, Akademicka 15, PL 20 950 Lublin

(Received: 20.11.2005)

S u m m a r y

Anemophilous trees of *Betula* and *Alnus* genera produce very high amount of easily spreading pollen. *Carpinus* and *Fagus* discharge lower amount of pollen to the atmosphere. Trees belonging to the mentioned genera occur in vegetation cover of Lublin and the Roztocze region where the comparative studies were carried out in the years 1998-2004. The objective of these studies was to determine pollen concentration of four tree taxa in these study areas located 120 km apart. Annual pollen sums, obtained by means of three methods, were compared in order to find similarity of alternating high and low pollen production by trees in particular years. In the Roztocze region the studies were continued during the mentioned seven years as a part of Pollen Monitoring Programme, which provides multi-annual data for the palaeoecological reconstructions of Quaternary and the interpretations of phenologic-climatic nature. Standard Tauber traps were used in the Roztocze area. In Lublin the gravimetric method was used in the years 1999-2000, and the volumetric method in the years 2001-2004. Similar trends were found in Lublin and in the Roztocze region as to the concentrations in the air of pollen of the mentioned four taxa in particular years of the research period. *Betula* and *Alnus* discharged the greatest amount of pollen. In 1999 the great similarity of annual pollen sums of three taxa was recorded by means of the gravimetric method in all measurement points. *Fagus* was an exception, as its pollen concentration was much higher in the Roztocze region than in Lublin. In the case of *Carpinus* the enhanced pollen concentration was

recorded in both study areas in 2002, and the highest concentration of *Fagus* occurred in 2003. During several years of studies we recorded great similarity of the obtained results in two study areas far apart.

Key words: pollen monitoring, modern pollen deposition, Tauber traps, actuopalynology

INTRODUCTION

In the last years the pollen production by plants have been studied in detail not only because of the increasing incidence of pollinosis, but also due to the usefulness of these investigations for palaeoecological research and reconstruction of palaeoclimatic conditions, and also for forecasting of climate changes in the future.

Different methods are practiced in order to accomplish the above-mentioned purposes. Dynamics of pollen concentration in the air and deposition during pollen seasons is studied for the purposes of allergology and phenology with the use of volumetric method (Hirst, 1952; Raynor, 1979; Käpylä & Penttinen, 1981), and more and more rarely the gravimetric method (Durham, 1964; Mandrioli et al., 1998).

Standard Tauber traps, basing also on gravimetric method (Hicks et al., 1996), are used in the studies aimed at palaeoecological reconstructions of the Quaternary. These studies are part of the international project Pollen Monitoring Programme (PMP), which is coordinated by the University of Oulu, Finland. The purpose of the PMP project is to count pollen deposition of different taxa of trees and other plants in the conditions similar to the natural ones (national parks, reserves) allowing rather objective interpretation of the features of local and regional vegetation and phenologic-climatic changes (Hicks et al., 1996; Broström, 2002).

Anemophilous trees discharge to the atmosphere very high amount of easily spreading pollen. The variability of pollen concentration in a specified volume of the air, recorded in particular years, is conditioned by biological and climatic factors (Latałowa et al., 2002; Spiekma et al., 2003).

In the studies, which were continued during seven years, there were compared the annual pollen sums of four taxa, i.e. *Alnus*, *Betula*, *Carpinus*, and *Fagus*, which occur in local flora of Lublin and the Roztocze region. The objective of this work was to find if during the study period the changes of pollen concentrations of the mentioned tree taxa were similar in two study areas located 120 km apart. Three methods were used to determine pollen concentration on a surface unit or in a specified volume of the air.

MATERIALS AND METHODS

As a part of the PMP, the monitoring of *Alnus*, *Betula*, *Carpinus*, and *Fagus* pollen deposition near Guciów village, in the protection zone of the Roztocze National Park, was carried out in the years 1998-2004. The PMP method consists in trapping

of plant pollen into standard Tauber traps (Tauber, 1974; Hicks & Hyvärinen, 1986), then in laboratory treatment of pollen material with the use of *Lycopodium* indicator tablets, and in microscopic analysis (Hicks et al., 1996; 1999). This method enables the calculation of pollen influx, i.e. the number of pollen grains of a given taxon deposited on 1 cm² of area in a given year.

In the first stage of fieldwork the traps are put in the ground so that only their openings are on the ground surface. The trap is a plastic container with the opening 5 cm in diameter, covered with wire net of large mesh. The trap bottom is covered with viscous fluid, which is a mixture of glycerine, formalin (preservative), and thymol (fungicide). Each trap rests in the ground for the whole calendar year since the October, i.e. the end of the pollen season, till the October of the next year.

The laboratory treatment of the pollen trap content consists in adding of five indicator tablets with *Lycopodium* spores (Stockmarr, 1971), filtration with the use of vacuum pump, and standard Erdtman's acetolysis. During the next stage, i.e. microscopic analysis, the number of pollen grains of a given taxon is calculated in relation to the number of indicator spores. The counted sum of tree and shrub pollen (AP) is at least 500 grains, and that of *Lycopodium* spores 100 grains. Then the pollen influx in a given year is calculated according to the following formula:

$$\text{Pollen influx} = [(\text{number of added } \textit{Lycopodium} \text{ spores} / \text{number of counted } \textit{Lycopodium} \text{ spores}) \times \text{number of counted pollen grains of a given taxon}] / \text{surface area of the trap opening.}$$

The results obtained for four traps of extralocal significance were compared. Two of them (No 6 and 7) are the so-called regional traps, i.e. placed in open communities, in plough lands or wastelands. Their contents represent regional pollen deposition, typical of a larger area. Two other traps (No 4 and 8) are placed in the large forest clearings about 80-100 m in diameter. They also collect extralocal pollen deposition. The results obtained for the rest of traps were not taken into account because they are placed in smaller clearings and their contents represent mostly local vegetation.

In some years it happened that the traps were destroyed or stolen in some sites and we had no results from them. And thus, in 1998 only two traps (No 4 and 6) survived, so the mean values of pollen deposition were calculated on the basis of only two results. This fact could have influenced the error of calculations. In 2000 none of regional traps (No 6 and 7) survived, so the pollen production was estimated only from the results obtained for two traps (No 4 and 8) in forest clearings, while in 2001 there was a lack of data for the trap No 8.

In the years 1998-2000 the pollen deposition in Lublin was monitored by means of the gravimetric method with the use of Durham sampler, which was placed at a height of 9 m in the Sławinek quarter. Samples were taken twice a week. Annual pollen sums of *Alnus*, *Betula*, *Carpinus* and *Fagus* were calculated, and expressed as the number of grains for 1 cm². In the years 2001-2004 the measurements were taken by volumetric method with the use of Lanzoni sampler, which was placed at a height

of 18 m in the Śródmieście quarter. Annual pollen sums of the mentioned tree taxa were expressed as the number of grains in 1 m³ of atmospheric air.

Location of the study area is presented in Fig. 1.

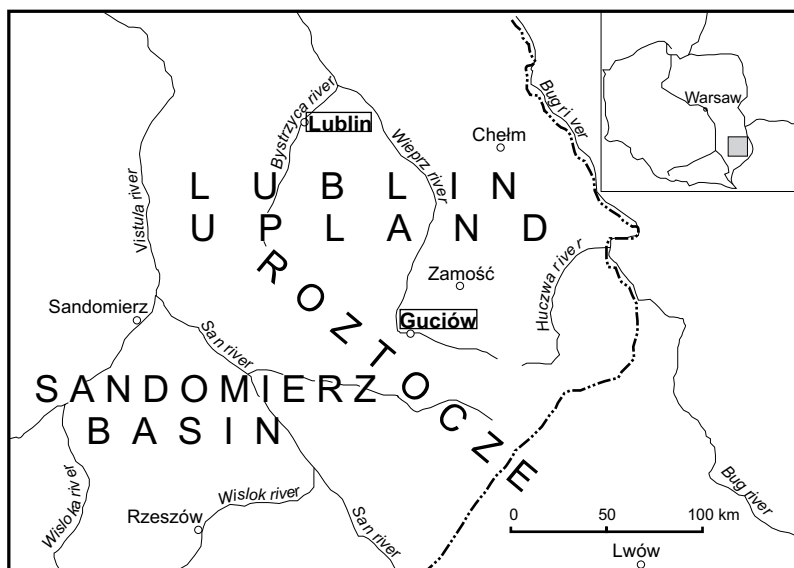


Fig. 1. Location of the study area.

In order to compare annual pollen deposition and airborne pollen concentration of each taxon, the percentage pollen index (PI) was calculated from the data obtained by means of three methods: PMP, gravimetric (with the use of Durham sampler), and volumetric (with the use of Lanzoni sampler). The calculations were done separately for three years (1998-2000) when the gravimetric method was used in Lublin, and separately for four years (2001-2004) when the volumetric method was practiced. The percentage pollen index (PI) was calculated according to the following formula:

PI = annual pollen sum in a given year / sum of pollen grains in three years' period (gravimetric method) or in four years' period (volumetric method).

In the PMP method the annual pollen sum was the average sum of pollen grains deposited per 1cm², calculated from the sums obtained in the four monitoring sites (except for 1998 and 2000 years, when the calculations were based on two monitoring sites only).

Table 1
Pollen sums and PI values for selected tree taxa in Lublin and Roztocze in the period
1998-2004.

Taxon name	Year	Lublin – annual pollen sum	Total sum (S) for 3 or 4 years	PI value	Roztocze – annual pollen sum	Total sum (S) for 3 or 4 years	PI value
Alnus	1998	1329	S=3423	38.80%	5374	S=6259.8	85.80%
	1999	390		11.40%	661.3		10.60%
	2000	1704		49.80%	224.5		3.60%
	2001	6216	S=21617	28.80%	2836.3	S=7700.8	36.80%
	2002	2545		11.80%	1372		17.80%
	2003	7095		32.80%	2323.5		30.20%
	2004	5761		26.60%	1169		15.20%
Betula	1998	1284	S=13455	9.50%	3380.5	S=10061.8	33.60%
	1999	3057		22.70%	2962.3		29.40%
	2000	9114		67.70%	3719		37.00%
	2001	13670	S=65805	20.80%	7458	S=29288.3	25.50%
	2002	5354		8.10%	2692.5		9.20%
	2003	34134		51.90%	15438.5		52.70%
	2004	12647		19.20%	3699.3		12.60%
Carpinus	1998	229	S=739	31.00%	1457.5	S=4553.3	32.00%
	1999	110		14.90%	416.8		9.20%
	2000	400		54.10%	2679		58.80%
	2001	661	S=2821	23.40%	645	S=4838.3	13.30%
	2002	1370		48.60%	2960		61.20%
	2003	466		16.50%	780		16.10%
	2004	324		11.50%	453.3		9.40%
Fagus	1998	10	S=70	14.30%	378.5	S=3292.5	11.50%
	1999	7		10.00%	209		6.30%
	2000	53		75.50%	2705		82.20%
	2001	57	S=524	10.90%	104.7	S=4112.8	2.60%
	2002	124		23.60%	1355.8		33.00%
	2003	310		59.20%	2009		48.80%
	2004	33		6.30%	643.3		15.60%

Lublin, situated in the Lublin Upland (Fig.1), and neighbouring it the Roztocze region differ somewhat in respect of climatic conditions. The climate of the Lublin region is under the influence of continental air masses. Vegetation season lasts here ca.215 days (Woś, 1999). Mean yearly air temperature calculated in the period

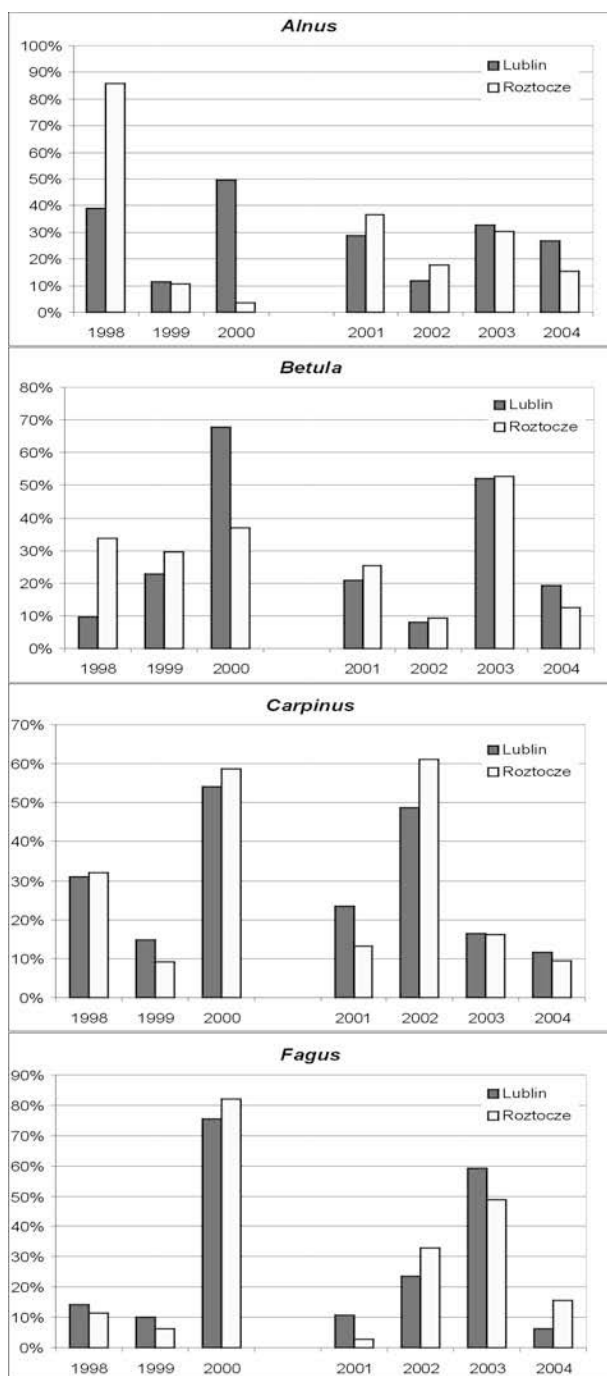


Fig. 2. PI values for *Alnus*, *Betula*, *Carpinus* and *Fagus* in Lublin and Roztocze in the period 1998-2004.

1951-1990 is 7.4°C. January is the coldest month with the mean temperature 3.8°C, and July is the warmest month with the mean temperature 17.8°C. Average yearly rainfall sum in Lublin (1951-1990) reaches 550 mm (K a s z e w s k i et al., 1995).

On the background of the climate of Poland, the Roztocze climate differs from other regions by the greater inflow of solar insolation especially during late summer and early autumn. Besides, yearly sums of rainfall are higher and near Guciów they reach as much as 650 mm. Mean air temperature in January is 4.3°C and in July 17.7°C. An unfavourable feature is quite great number of days with frost when the maximum daily temperature is below 0°C. Such days occur even in May, especially in valley bottoms (K a s z e w s k i et al., 2002).

RESULTS AND DISCUSSION

The analyses showed that *Betula* discharged the greatest amount of pollen from among four taxa in the studied areas. Annual pollen sum of *Alnus* is several times smaller. The comparison of annual pollen sum totals for four years (2001-2004), when in Lublin the volumetric method was used, revealed that the number of pollen grains of *Betula* was 3 and 3.8 times greater than that of *Alnus* in Lublin and in the Roztocze, respectively. *Carpinus* and *Fagus* discharged many times smaller amount of pollen than *Betula* (Table 1).

Similar trends were found in Lublin and in the Roztocze region as to the pollen concentrations of mentioned four taxa in particular years of the research period. It is illustrated by the percentage pollen index (PI) calculated for individual years in the two study areas. In both areas, the obtained values of PI were very similar (Table 1). The PI values for *Alnus* were similar in 1999 and 2003, for *Betula* in the 2001-2003 period and those for *Carpinus* in the years 1998, 2000, 2003 and 2004. Somewhat greater differences concerned the PI values of *Fagus* found in particular years in both areas, but still the trends in the values of pollen concentration of this taxon are identical. The only exception from this rule is the reverse tendency shown by *Alnus* and *Betula* pollen in 1998 and 2000.

In the years 1998-2000 the gravimetric method was used in Lublin, and the PMP method (basing also on gravimetric one) in the Roztocze region. In these years, a great similarity of the annual pollen sums was obtained with respect to *Carpinus* and *Fagus*. The differences did not exceed 5% except for 2000 year when the annual pollen sum for *Fagus* made up for 75.5% and 82.2% of the total sum based on the three year calculations in Lublin and in the Roztocze region, respectively.

In 1999 the great similarity occurred in PI values also for *Betula* and *Alnus* (Table 1, Fig. 2). The differences did not exceed 1%. However, in 1998 the pollen indices of both taxa were much higher in the Roztocze region, while in 2000 in Lublin. Such discrepancy in the results, exceeding several tens percent, may be caused, among other things, by the lack of data from the two damaged traps in each of these years.

However, when volumetric method was used in Lublin, i.e. in the years 2001-2004, greater similarity was found with respect of annual pollen sums of all four analyzed taxa in both areas (Table 1, Fig. 2). The differences in PI values oscillate from 0.4 to 12.6%. This fact can indicate greater accuracy of the results obtained with the use of the volumetric method. It should be also stressed that the data series is more complete (one season more). The only lack of data concerns the trap no 8 in 2001. The best conformity between the results occurred with reference to *Alnus* and *Betula*, while differences ca. 10% were noted when PI values for *Carpinus* and *Fagus* were compared. Nevertheless, the differences in annual pollen sums calculated for hornbeam and beech in Lublin and in the Roztocze region are considered to be small. They can result from different participation of these two trees in vegetation cover of the studied areas. *Carpinus* and *Fagus* trees are more frequent in the Roztocze region (Zając & Zając, 2001) where *Fagus sylvatica* forms almost single-species stands of the Carpathian beech wood. Its eastern tree line runs across the Roztocze region (Szweykowska & Szweykowski, 1993). *Carpinus betulus* occurring frequently in forest borders in the Roztocze region produces more pollen and fruits than the specimens growing in dense forest due to sufficient insolation (Suszka, 1993).

With respect of *Betula*, biannual cycle of abundant pollen production was found earlier by several authors (Spieksma et al., 1995; Corden et al., 2000; Latałowa et al., 2002). Higher concentrations of *Betula* and *Alnus* pollen were recorded both in Lublin and in the Roztocze region in some years (for example 2001 and 2003).

The cycles of pollen deposition were more difficult to determine with respect of taxa discharging a smaller amount of pollen, to which *Carpinus* and *Fagus* belong. However, the years of high pollen concentration were found for each of them during the seven-year period. In the case of *Carpinus*, it was 2002 year, both in Lublin and in the Roztocze region. The highest concentrations of *Fagus* pollen were recorded in 2000 and 2003 (Table 1). Worthy noticing is also quite great similarity of PI values obtained for *Fagus* in both areas, in spite of its much more numerous occurrence in the Roztocze.

The intensified tree pollen concentration in some years can be favoured by weather conditions, in it insolation (Spieksma et al., 2003), and by the features associated with biology of tree development, i.e. alternating production of large assimilation surface of leaves and high number of inflorescences in successive years (Dahl & Strandhede, 1996). In the opinion of other authors (Hicks et al., 1994), high pollen production resulting in rich fruiting needs much energy in a given year, and causes development inhibition of flowers in next year. Moreover, abundant beech pollen production seems to depend on higher than average July temperature of the previous year when pollen grains begin to form in the inflorescences (Chłupka, 1990).

To sum up, during seven years of studies we recorded rather great similarity of the obtained results in two areas with slightly different climatic conditions, and very different vegetation cover, located 120 km apart. The applied methods were also different. Despite these differences, the recorded similar trends in pollen values (PI) indicate the occurrence of regional factors, which influence the production of pollen by trees of the examined taxa.

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Porównanie koncentracji ziarn pyłku wybranych taksonów drzew w Lublinie i na Roztoczu przy zastosowaniu trzech metod badań

Streszczenie

Wiatropyłne drzewa z rodzaju *Betula* i *Alnus* produkują bardzo duże ilości łatwo rozprzestrzeniającego się pyłku. Mniej ziarn pyłku uwalniają do atmosfery *Carpinus* i *Fagus*. Drzewa należące do wymienionych rodzajów są reprezentowane w roślinności Lublina i na Roztoczu, gdzie przeprowadzono badania porównawcze. Celem badań było określenie koncentracji pyłku czterech taksonów drzew w latach 1998-2004 w dwóch punktach pomiarowych, oddalonych od siebie o 120 km. Porównywano roczne sumy ziarn pyłku uzyskane przy zastosowaniu trzech metod, aby ustalić stopień zgodności w zakresie przemienne występującego u drzew obfitego i słabego pylenia w poszczególnych latach. Na Roztoczu badania prowadzono w ciągu siedmiu wymienionych lat w ramach Pollen Monitoring Programme, który zmierza do dostarczenia wieloletnich danych wykorzystywanych do rekonstrukcji paleoekologicznych czwartorzędu oraz do interpretacji o charakterze fenologiczno-klimatycznym. Stosowano tu standardowe pułapki pyłkowe typu Taubera. W Lublinie w latach 1999-2000 prowadzono badania metodą grawimetryczną, zaś w latach 2001-2004 metodą wolumetryczną. Stwierdzono, że w Lublinie i na Roztoczu zaznaczyły się podobne tendencje w zakresie zawartości ziarn pyłku w powietrzu wymienionych taksonów w poszczególnych latach badań. *Betula* i *Alnus* uwalniały największe liczby ziarn pyłku. W roku 1999 przy stosowaniu metody grawimetrycznej, we wszystkich punktach pomiarowych wykazano dużą zbieżność wyników dotyczących wysokości sum rocznych ziarn pyłku dla trzech taksonów. Wyjątek stanowił *Carpinus*, u którego produkcja pyłku była znacznie większa na Roztoczu niż w Lublinie. W przypadku *Carpinus* wzmożoną produkcję pyłku notowano w obu punktach badawczych w 2002 roku, zaś pyłek *Fagus* pojawił się najobficiej w roku 2002 i 2003. W ciągu kilku lat badań zarejestrowano dużą zgodność uzyskanych wyników w znacznie oddalonych od siebie punktach badawczych.