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Results of research on pollen fall-out in the atmospheric ground layer

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Abstract

The paper covers results of observations on the distribution of tree and herbaseous plants' pollen in the lower atmospheric layer at various heights in the three-year period 1966—1968. On the basis of the material obtained a calendar of pollen appearance was prepared.

INTRODUCTION

Investigations on pollen fall-out have been carried on for many years, in Poland, however, only few papers are devoted to this problem. Bremówna and Sobolewska (1939) investigated pollen fall-out in the Białowieża virgin forest, similar studies on *Quercus* and *Pinus* pollen distribution were performed by Borowik (1963 and 1966). Also Dyakowska studied the rate of pollen fall from certain trees (1937) and pollen rain on the sea and on the coast of Greenland (1948). Numerous authors have elaborated this problem in England, the United States and other countries. Among the most recent publications should be quoted the papers by Tauber (1967) and by Fendrik and Glubrecht (1967).

Research on pollen fall-out in the atmosphere was started in the Regional Station of the Polish State Hydrometeorological Institute at Mikołajki in 1966 and continued up to 1968. The distribution of pollen in the atmospheric ground layer was examined at three heights and a calendar of pollen appearance was prepared for the years 1966, 1967 and 1963.

SITE OF OBSERVATION

Within the grounds of the Meteorological Station three observation sites were chosen at the height of 0.60, 1.40 and 12.00 m. *Salix* grows at a distance of about 20 m from these sites and further there are *Pirus* and *Crategus*. On the same side about 100 m distant is a belt of coastal vegetation along the lake, composed of *Alnus* and *Salix* with two *Ulmus* specimens. The lake is 500 m wide at this point and on its other side a pine forest spreads forming part of the Puszcza Piska virgin forest complex. To south east experimental plots of the State Hydrometeorological Institute, and further cultivated land and pastures extend. On the north-eastern side of the Station there are some buildings between which *Betula* and *Larix* grow, beyond them are two groups of trees composed *Populus, Robinia* and *Acer*, bordered by a 700-m track of arable land. The station is separated from the town of Mikołajki on the northern and western side by a 300-m wide belt of pastures. On the same side at a distance of 1000 m there is *Carpinus* plantation and single *Tilia, Acer* and *Fraxinus* speciments, and at a distance of 2000 m *Betula* and limo--maple alley. The most common herbaceous plants around the Station are: *Gramineae, Plantago, Taraxacum, Artemisia, Cichorium, Rumex, Urtica, Equisetum.*

MATERIAL AND METHODS

In the course of the three years of observation the pollen of 15 genera of trees was determined (Table 1). The pollen of herbaceous plants (Table 2) was taken into account only if it was found in larger quantities or was the only representative of the given family. The remaining genera which contributed only small quantities of pollen to the fall-out are listed jointly as families. Grasses were not classified into separate genera, only rye was listed separately in 1967 and 1968. The spores of *Equisetaceae* and *Polypodiaceae* were included in the herbaceous plants.

The pollen was caught on glasses coated with glycerin and gelatin. The glasses were changed daily at 7 a.m. The pollen was determined according to standards prepared from the plants flowering in the neighbourhood, at a × 500 magnification. Only beech pollen was determined without standard on the basis of a description. The pollen grains were counted on the coated 10-sq. cm surface of the coverslip. At the same time phenological observations of plants chosen within a 2-km radius were made.

Table 1

Number of tree pollen grains fallen off at various heights per 10 sq.cm surface in the years 1966—1968

Genus	Height in metres			Total	Percentage
	0.60	1.40	12,00		
Alnus	965	1 218	2 388	4 571	11.56
Corylus	218	252	696	1 166	2.95
Betula	544	1 270	2 949	4 763	12.04
Salix	1 464	382	337	2 183	5.52
Carpinus	94	192	461	747	1.89
Larix	—	1	4	5	0.01
Fraxinus	11	54	70	135	0.34
Acer	22	8	9	39	0.10
Fagus	19	28	22	69	0.17
Quercus	79	84	124	287	0.73
Pinus	6 362	8 704	9 698	24 764	62.60
Picea	168	75	177	420	1.06
Tilia	15	17	64	96	0.24
Populus	95	75	106	276	0.70
Pirus	5	18	12	35	0.09
Total	10 061	12 378	17 117	39 556	100.00
Percentage	25.4	31.3	43.3	100.0	

Table 2

Number of pollen grains of herbaceous plants fallen off at various heights per 10 sq.cm surface in the years 1966—1968

Family or Genus	Height in metres			Total	Percentage	Notes
	0.60	1.40	12.00			
Gramineae	3 801	3 502	2 880	10 183	51.95	without *Secale*
Secale	1 415	864	944	3 223	16.44	
Compositae	529	232	142	903	4.61	without *Artemisia*
Artemisia	675	1 364	512	2 551	13.01	
Chenopodiaceae	64	105	40	209	1.07	
Umbelliferae	165	133	20	318	1.62	
Plantago	534	581	376	1 491	7.61	
Urtica	77	109	42	228	1.16	
Typha	3	2	—	5	0.03	
Rumex	66	175	63	304	1.56	
Equisetaceae	27	90	36	153	0.78	
Polypodiaceae	20	10	2	32	0.16	
Toatal	7 376	7 167	5 057	19 600	100.00	
Percentage	37.6	36.6	25.8	100.0		

RESULTS OF OBSERVATION

Pollen density at various levels

Over the entire observation period 59 156 pollen grains were counted including 39 556 (66.8%) of tree pollen, and 19 600 (33,2%) of herbaceous plants. No major differences were noted in general pollen density in dependence on height, but the composition differed widely (Table 3). Tree pollen density was highest at the height of 12.00 m and lowest at the 0.60-m level. The maximum of pollen fall-out of herbaceous plants could not be clearly established, and the minimum was found at 12.00 m.

Analysis of pollen fall-out from trees shows certain variations in the particular years. *Alnus* pollen in 1966 and *Salix* pollen in 1966 and 1968 were most profuse at the height of 0.60 m. On the other hand, *Pinus* pollen in 1967 and *Betula* pollen in 1968 was present in larges quantities at a height of 1.40 m (Fig. 1).

From among herbaceous plants, *Artemisia* pollen was most constantly distributed with maximum in all three years at the 1.40 m level. For all the remaining plants maximum varied in the particular years, never, however, appearing at a height of 12 m (Fig. 2).

Calendar of pollen appearance

On the basis of the material collected at three levels mean values were calculated for preparing a calendar of pollen appearance for the years 1966—1968 (Fig. 3). It results from the data available that pollen begins to appear in the atmosphere in March and disappears in September. In winter months only single sporadis grains of pine and grass pollen may be found, therefore these months are not included in the calendar.

The annual fall-out may be divided into the period of tree pollen appearance lasting from March to mid June, and the period of appearance of herbaceous plants pollen lasting from June to mid September. The first ten days of June constitute the intermediate period when mass grass pollen appearance coincides with profuse pine pollen emission.

The earliest to apper is *Corylus* and *Alnus* pollen, next comes that from *Populus, Salix, Betula, Carpinus* and *Fraxinus*, and last from *Quercus, Picea* and *Pinus*. From among herbaceous plants most common is the pollen of *Compositae* (*Taraxacum*), *Equisetum* and *Gramineae*. The period of mass apperance of the pollen of particular tree genera is short lasting, from several to about 2—3 weeks. Fall-out is considerable reaching 99 grains per 1 sq. cm in 24 h. From among all tree pollens, pine pollen is most profuse (62.6%). This is quite understandable since pines constitute about 72 per cent of the forest stands. The period of appearance of pollen of herbaceous plants is much more protracted lasting for grasses

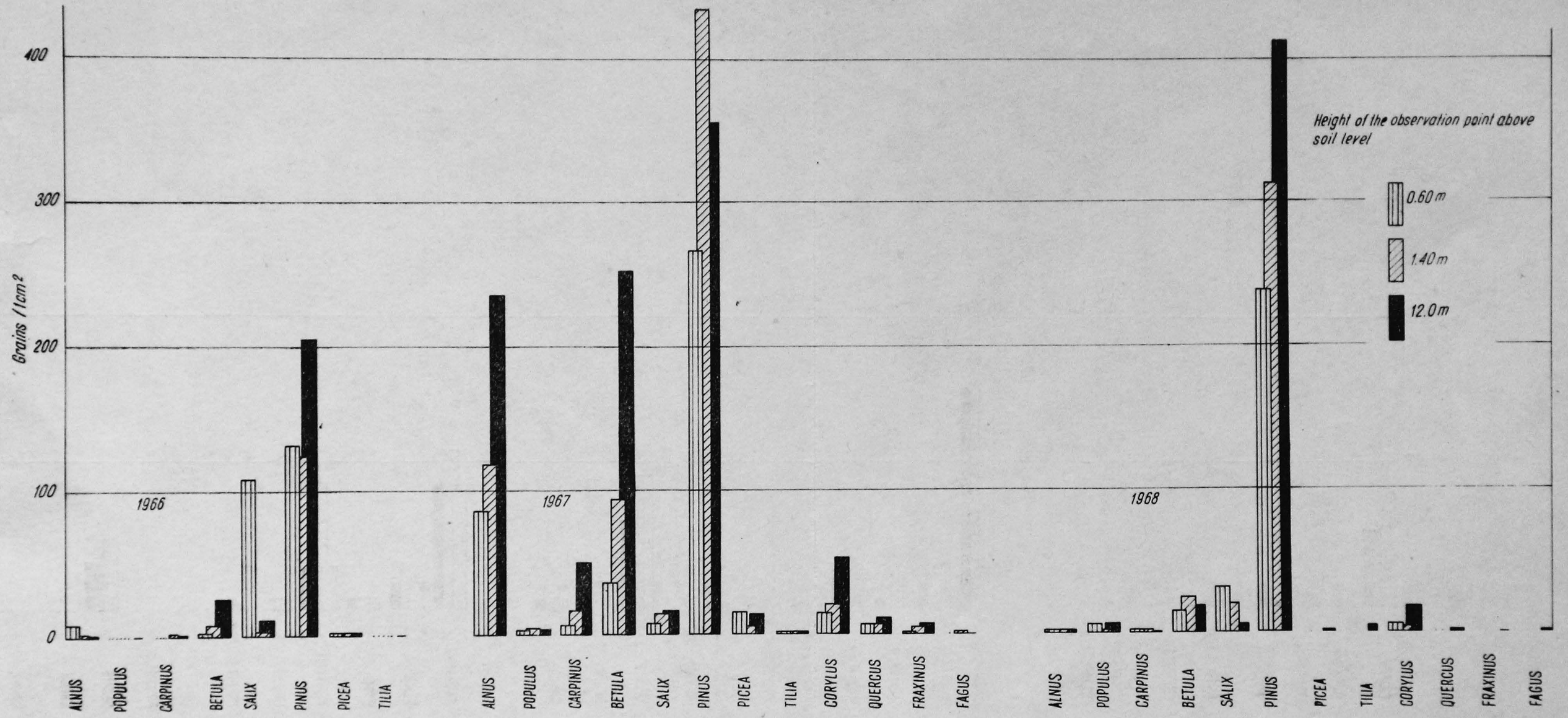


Fig. 1. Fall-out of tree pollen per 1 sq. cm surface at various heights in Mikołajki during three years

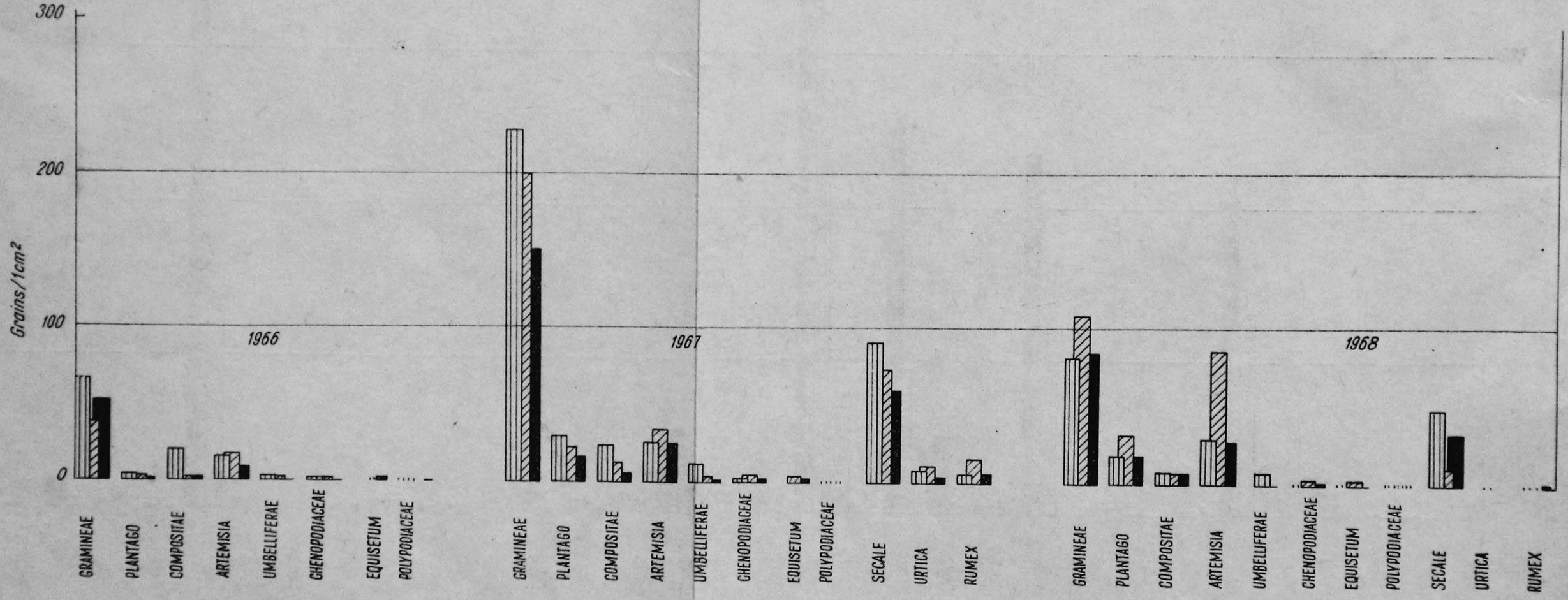


Fig. 2. Fall-out of green plants pollen per 1 sq. cm surface at various heights in Mikołajki during three years

up to five months. Two maxima can be distinguished in this period: the first abundant appearance in June lasting to fid July, and the second between the end of August and beginning of September. Among herbaceous plants grass pollen is most numerous and that of *Artemisia* ranks second. Within the Station grounds *Plantago lanceolata* is abundant but contrary to the findings of Hyde and Williams (1946) its pollen was not found in greater quantities.

If we compare the dates for the particular years, distinct differences may be noted in the date of appearance of *Alnus* and *Corylus* pollen, reaching from several to more than twenty days. This is no doubt due to temperature variations (Table 4). In 1966 mean air temperature in the second 10 days of March was negative, whereas in 1967 in all three ten-day periods of this month it was positive exceeding 3°C, and this was reflected in the early appearance of pollen from the above mentioned trees.

Beside differences in time, there also appeared quantitative differences. It is not difficult to explain these variations for trees and some herbaceous plants. The relatively small amount of grass pollen in the years 1966 and 1968 was due to the fact that part of the meadows had been mown in these years before bloom, whereas in 1967 grass was cut on the meadows at the moment of full flowering. The greater distance of the experimental

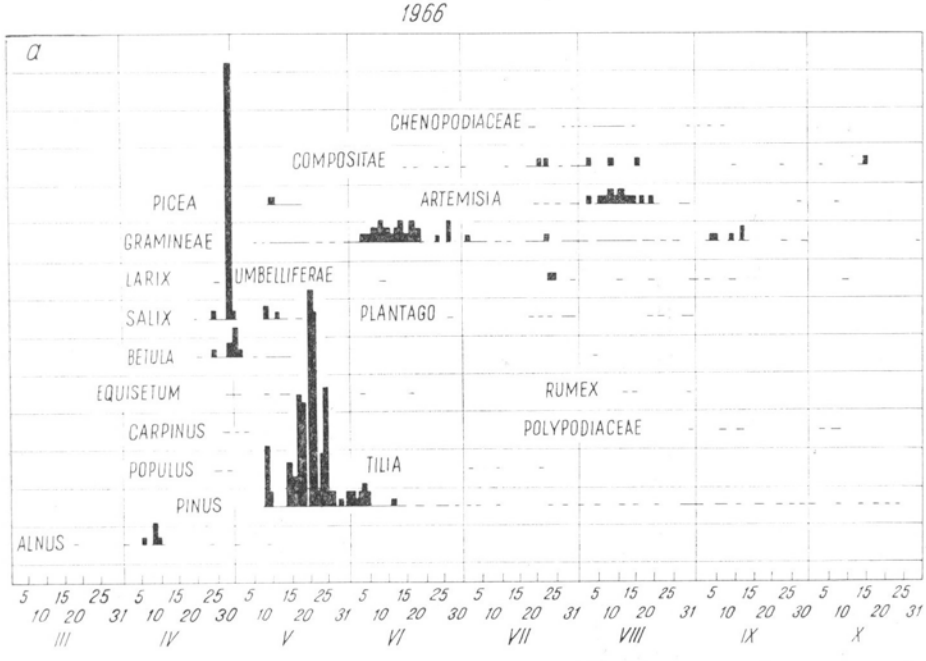
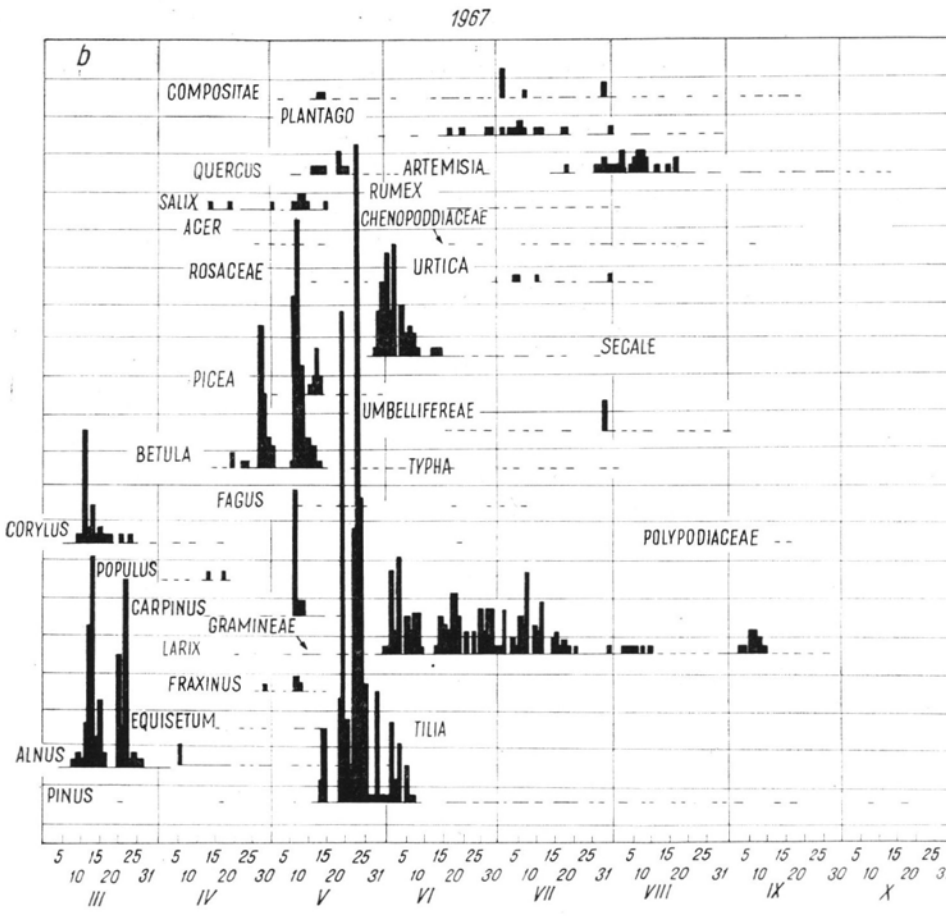
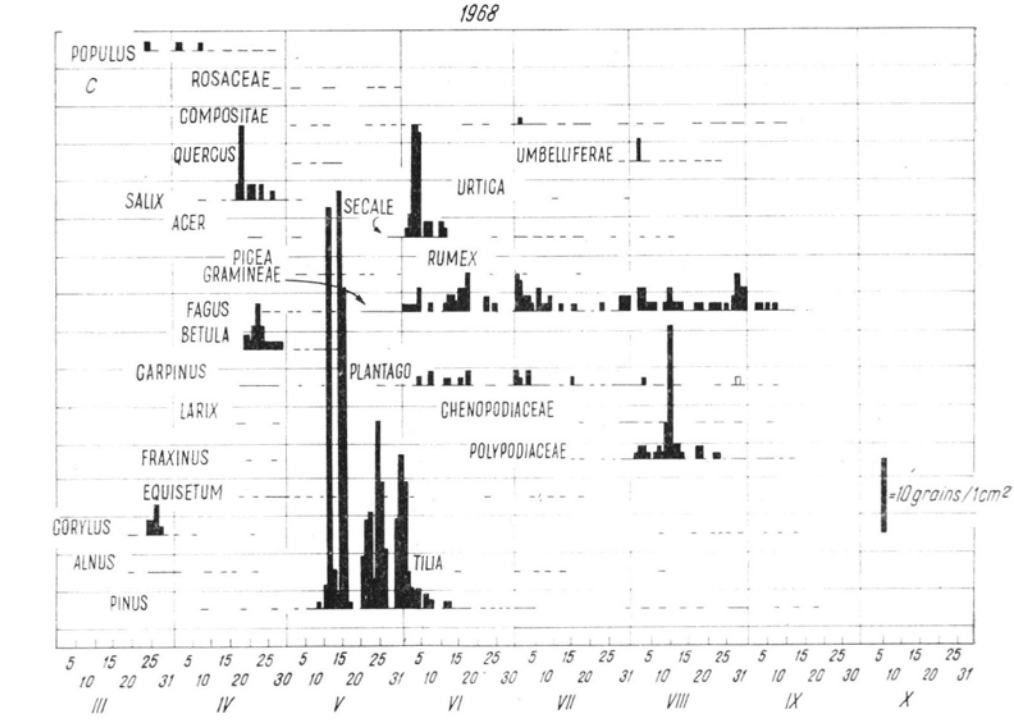


Fig. *a*, *b* and *c*. Calendar of pollen appearance in Mikołajki in the three years 1966, 1967 and 1968


1967
b
COMPOSITAE
PLANTAGO
QUERCUS
ARTEMISIA
SALIX
RUMEX
ACER
CHENOPODIACEAE
ROSACEAE
URTICA
SECALE
PICEA
UMBELLIFEREAE
BETULA
TYPHA
FAGUS
CORYLUS
POLYPODIACEAE
POPULUS
CARPINUS
GRAMINEAE
LARIX
FRAXINUS
EQUISETUM
TILIA
ALNUS
PINUS
5 15 25 5 15 25 5 15 25 5 15 25 5 15 25 5 15 25 5 15 25 5 15 25 5 15 25
10 20 31 10 20 30 10 20 31 10 20 30 10 20 31 10 20 31 10 20 30 10 20 31
III IV V VI VII VIII IX X


1968
POPULUS
C
ROSACEAE
COMPOSITAE
QUERCUS
UMBELLIFERAE
SALIX
URTICA
SECALE
ACER
PICEA
RUMEX
GRAMINEAE
FAGUS
BETULA
CARPINUS
PLANTAGO
LARIX
CHENOPODIACEAE
FRAXINUS
POLYPODIACEAE
EQUISETUM
=10 grains/1cm²
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ALNUS
TILIA
PINUS
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III IV V VI VII VIII IX X

Table 3

General total of pollen fallen off at various heights per 10 sq. cm surface in the years 1966—1968

Pollen	Height in metres			Total	Percentage
	0.60	1.40	12.00		
Trees	10 061	12 378	17 117	39 556	66.9
Herbaceous plants	7 376	7 167	5 057	19 600	33.1
Total	17 437	19 545	22 174	59 156	100.0
Percentage	29,5	33,0	37,5	100,0	

Table 4

Mean ten-days air temperatures in the spring months 1966 — 1968 in Mikolajki

Year	Decade	Months		
		March	April	May
1966	I	2.2	5.7	12.9
	II	—0.3	2.5	14.9
	III	2.4	9,8	10,7
1967	I	3.9	4.3	10.8
	II	3.4	7.2	15.2
	III	3.6	7.1	14.2
1968	I	—3.1	4.9	12.3
	II	—0.1	6.1	10.3
	III	7.9	11.9	10.7

plot with rye in 1966 from the observation site as compared with that in other years reduced the rye pollen incidence, and for this reason rye was included among grasses in that year. The fall-out in 1968 did not contain any *Alnus* pollen, and it was found that in this year *Alnus* did not flower. The contribution of *Picea* pollen to the fall-out was very small, although, according to the data of the Forest Inspectorate Mikołajki, *Picea* is second as regards frequency in the local stands. Some light is thrown on this problem by Ambach, Bortenschlager and Eisner (1969). These authors noted that the mass appearance of *Picea* pollen occurs at intervals of 4—8 years. In between the amount of pollen is negligible. It is, therefore, possible that the investigations in Mikołajki fell to the period of rest of *Picea*.

The reason for the relatively low amount of *Betula* pollen in 1968 is not known, since *Betula* flowered quite profusely in this year. Neither can the small quantity of *Populus* pollen be explained in view of intensive flowering of these trees in all the years of the study. It was to be expected that, on account of the close vicinity of *Populus* at the

observation site (ca. 100 m) there will be a profusion of this pollen. The absence of *Larix* pollen in the fall-out is strange since the trees flowered in 1967 profusely, whereas only a single grain was found.

CONCLUSIONS

1. There are no major differences in pollen density at the height of 0.60, 1.40 and 12.00 m, but the composition of the fall-out differs widely.

2. The tree pollen amount increases with the height level. Variations in this respect in particular years concern in the first place genera growing in close vicinity to the observation points.

3. The fall-out of herbaceous plants pollen is lowest at the 1200 m level. The maximum, however, is difficult to establish since in particular years it varied for the different plants between 0.60 and 1.40 m. The only exception was *Artemisia* pollen with a maximum consistently at 1.40 m.

4. The pollen period in the area of Mikołajki lasts from March to September. In its first part tree pollen is most abundant, and the contribution from herbaceous plants is but small. In the second part of this period (June-September) pollen of herbaceous plants prevails and tree pollen forms a small admixture. The earliest tree pollen appearing in spring is that from *Alnus* and *Corylus*, and, as regards herbaceous plants, from *Taraxacum*.

5. The date of pollen appearance from early blooming plants is very much dependent on air temperature.

6. Wide differences in pollen fall-out in the particular years are the result of both biological factors (not all trees flower every year and the intensity of flowering varies) and the activity of man (mowing, crop rotation).

7. In view of the absence of *Larix* pollen in the fall-out and of the small quantity of *Populus* and *Betula* pollen in spite of occurrence of these trees at a small distance from the observation point, it would be interesting to investigate the cause of this phenomenon.

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Wyniki badań nad opadem pyłku w przyziemnej warstwie atmosfery

Streszczenie

Badania nad ilością pyłku prowadzono od 1966 do 1968 r. w Obserwatorium Regionalnym Państwowego Instytutu Hydrologiczno-Meteorologicznego w Mikołajkach. W wyniku tych prac zbadano rozmieszczenie pyłku w przyziemnej warstwie atmosfery na trzech wysokościach oraz sporządzono kalendarz pyłkowy (dla lat: 1966, 1967, 1968).

Z przeprowadzonych badań można wyciągnąć następujące wnioski:

1. Nie ma dużych różnic w ogólnym zagęszczeniu pyłku na wysokości 0,60 m, 1,40 m i 12,00 m, natomiast w jego składzie występują duże różnice.

2. Ilość pyłku drzew rośnie ze wzrostem poziomu. Odchylenia od tego w poszczególnych latach dotyczą przede wszystkim rodzajów rosnących w bliskim sąsiedztwie stanowisk obserwacyjnych.

3. Opad pyłku roślin zielnych osiąga minimum na wysokości 12,00 m. Nie można jednak określić gdzie przypada maksimum, gdyż w poszczególnych latach u wszystkich roślin wahało się między 0,60 m a 1,40 m. Wyjątek stanowił pyłek bylicy, którego maksimum stale występowało na wysokości 1,40 m.

4. Rok pyłkowy w okolicy Mikołajek trwa od marca do września. W pierwszej połowie roku występuje masowo pyłek drzew, a tylko nieznacznie pyłek roślin zielnych. W drugiej połowie (czerwiec—wrzesień) w czasie masowego pojawu pyłku roślin zielnych pyłek drzew stanowi bardzo małą domieszkę. Z drzew najwcześniej pojawia się pyłek olchy i leszczyny z roślin zielnych pyłek mniszka.

5. Moment pojawu pyłku roślin kwitnących wczesną wiosną jest szczególnie uzależniony od temperatury.

6. Duże różnice w opadzie pyłku w poszczególnych latach są wynikiem zarówno czynników biologicznych (nie wszystkie drzewa kwitną co roku i nie jednakowo intensywnie), jak też działalności człowieka (koszenie, płodozmian).

7. W związku z brakiem w opadzie pyłku modrzewia i małej ilości pyłku topoli i brzozy, mimo występowania tych drzew w niedużej odległości od miejsca obserwacji, byłoby interesujące prześledzenie przyczyn tego zjawiska.