



Occurrence of airborne *Cladosporium* and *Alternaria* spores in Southern and Central Poland in 1995–1996

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Abstract

The concentration of airborne spores of *Cladosporium* and *Alternaria* has been investigated at five monitoring stations situated in cities from the foot of the Tatra Mountains to central Poland along a south-north transect (Zakopane, Kraków, Ostrowiec Świętokrzyski, Warszawa, Poznań) i.e. from a height of 900 m to 80 m above sea level. The aerobiological monitoring of fungal spores was performed by means of five Burkard volumetric spore traps.

Cladosporium spores were dominant at all the stations. The highest *Cladosporium* and *Alternaria* spore concentrations were observed at all the sites in July and August, except at Warszawa in both years and at Poznań in 1995 where the maximum of *Cladosporium* spores occurred in June and July, and at Ostrowiec Świętokrzyski in 1995 where the maximum was found in July, August and September.

Fungal spore concentrations in Zakopane and Kraków were significantly lower than those in Ostrowiec Świętokrzyski, Warszawa and Poznań and periods of abundant *Cladosporium* spore occurrence were different in these two groups of monitoring stations.

1. Introduction

The first investigations of airborne fungal spores in Poland were carried out in the cities of Kraków and Rabka in 1960 (Weiss, 1962). Fifteen types of fungal spores were identified then, including *Cladosporium* which had the highest concentration in the total spore count. Studies of the concentration of fungal spores performed to date in Poland refer to outdoor analyses (Gawet et al., 1996) as well as indoor analyses (Mędreła-Kuder, 1991). Many surveys of the occurrence of *Cladosporium* spores in different regions of the world clearly show their dominance in comparison with other spores (Mitakakis et al., 1997; Shaheen, 1992). However, in the United States, various surveys have reported *Alternaria* more frequently than other moulds (except on the Pacific Coast where this taxon was found only sporadically or in reduced numbers

(Prince and Meyer, 1976)). Even though mould spores are present in the air in concentrations considerably greater than those of pollen grains, the frequency of allergic respiratory diseases due to moulds is usually much lower than that due to pollen grains of vascular plants (D'Amato and Spieksma, 1995).

The most important fungal allergen sources are found among the fungi from the class of the *Deuteromycetes*. For *Alternaria* and *Cladosporium* regarded as the main allergenic fungi, threshold concentrations for evoking allergic symptoms are estimated to be 100 spores m⁻³ air and 3000 spores m⁻³ air respectively (Gravesen, 1979). The main reason for different threshold values of *Cladosporium* and *Alternaria* spores is that volumes of these particles are different: 10–20 *Cladosporium* spores may correspond to one *Alternaria* spore.

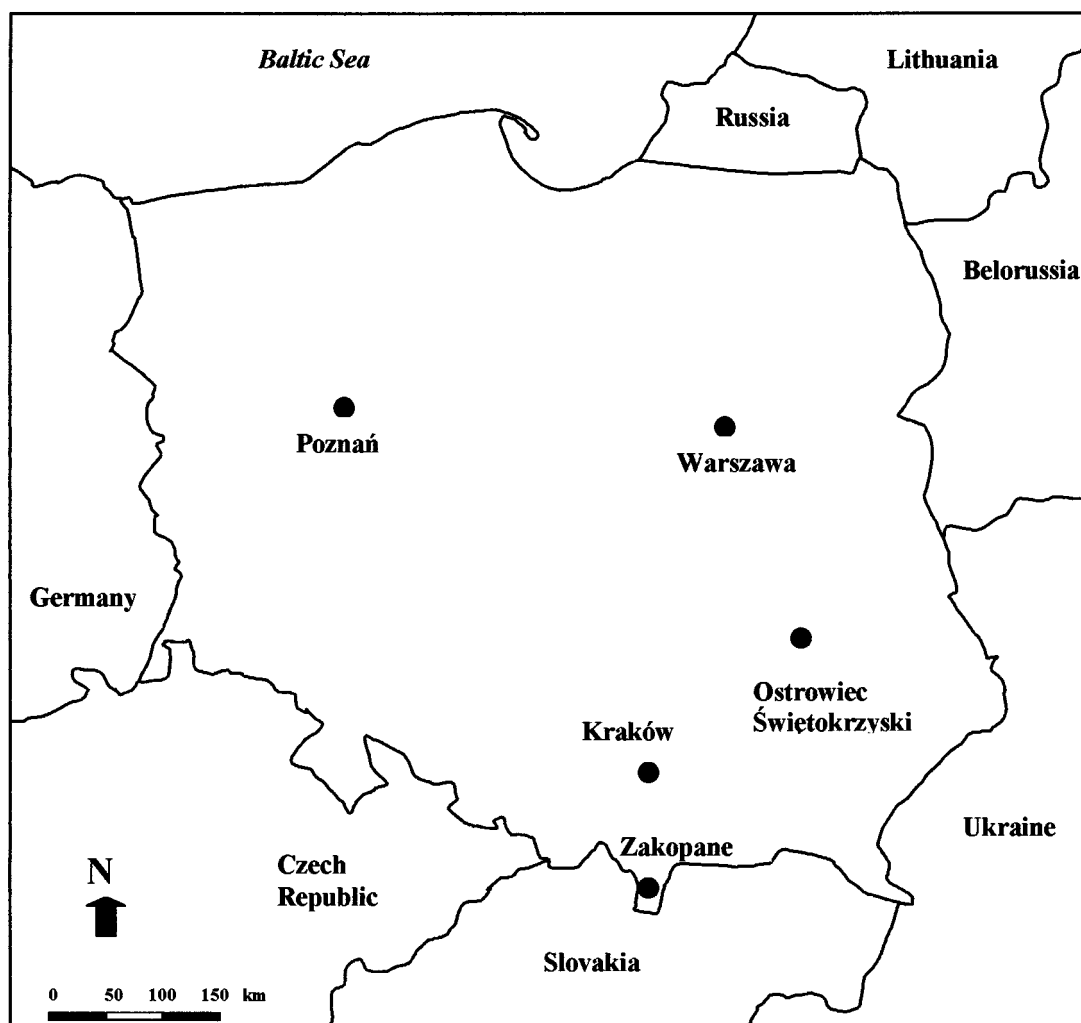


Figure 1. Map of Poland showing the monitoring sites and their coordinates: Zakopane – 900 m a.s.l.; 49°18'N, 19°58'E; Kraków – 220 m a.s.l.; 50°03'N, 19°57'E; Ostrowiec Świętokrzyski – 175 m a.s.l.; 50°58'N, 21°23'E; Warszawa – 100 m a.s.l.; 52°15'N, 21°00'E; Poznań – 80 m a.s.l.; 52°25'N, 16°55'E.

They seem to be responsible for clinical symptoms of oculorhinitis and/or bronchial asthma (D'Amato and Spieksma, 1995).

In clinical observations performed in Greece it has been established that even though *Cladosporium* spores are present in the air in high values they affect only half as many patients as the considerably lower concentration of *Alternaria* spores (Gioulekas et al., 1995). Similar results related to lower allergen activity of *Cladosporium* have been reported in Italy (Palmas et al., 1997) where patients sensitive to *Cladosporium* showed sensitivity to other allergens at the same time and the level of reaction was reasonably low, while almost one third of the patients sensitive to *Alternaria*

did not show sensitivity to other allergens and the level of reaction was always high.

According to recent studies of allergy to *Alternaria* and *Cladosporium* in children under the age of 4 on the Isle of Wight, these spores are the third most common reason for symptoms of asthma, eczema and rhinitis following house dust mite and grass pollen (Tariq et al., 1996).

2. Material and methods

The investigation of the concentration of spores of *Cladosporium* and *Alternaria* in the atmosphere

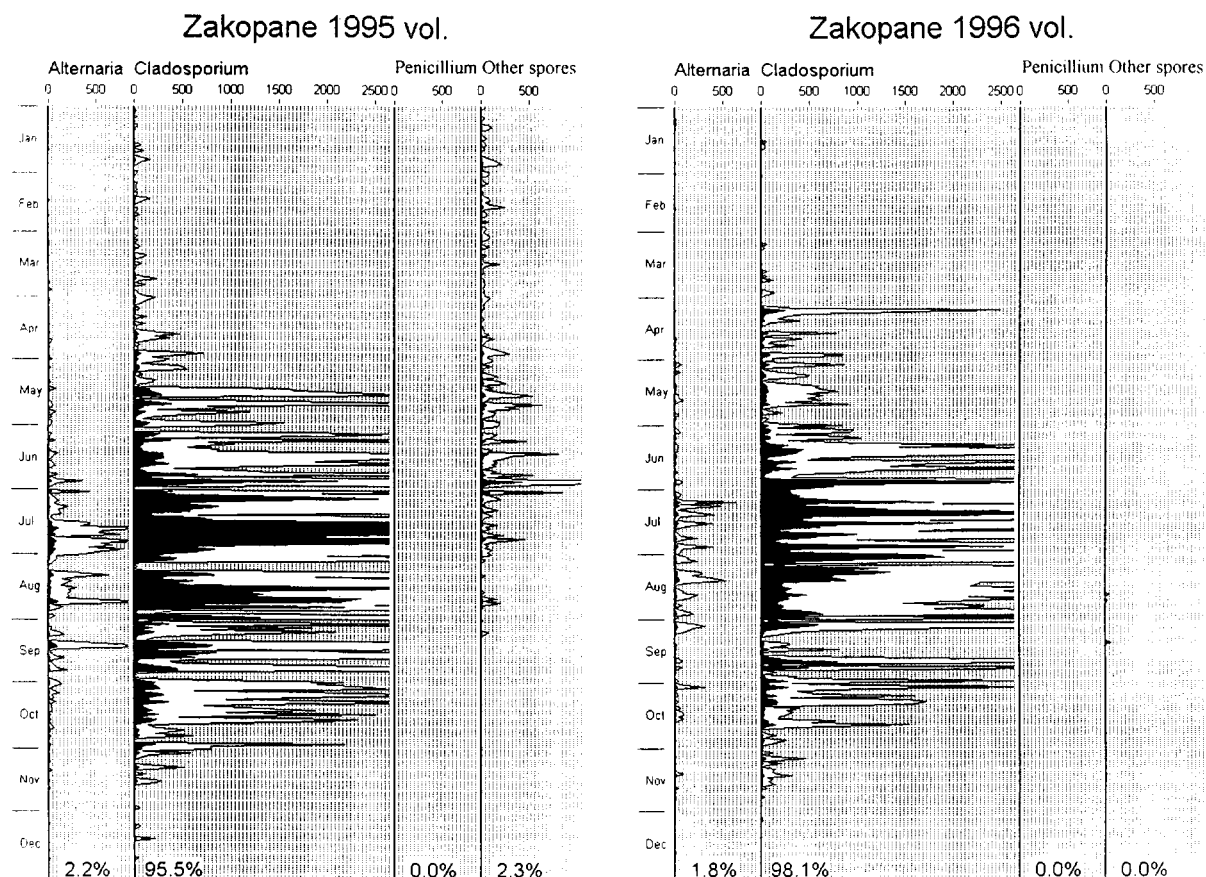


Figure 2. Absolute values of fungal spores in Zakopane (percentage of taxa of annual sums of daily average concentrations) in 1995–1996. Black area: number of spores m^{-3} air, white area: 10-fold enlargement of absolute values.

were carried out in five cities in Poland along a south-north transect (Zakopane, Kraków, Ostrowiec Świętokrzyski, Warszawa, Poznań) in 1995–1996 (Figure 1).

Northern Poland was excluded from our net of sampling sites because in the Gdańsk-Gdynia area (stretching along the 30 km shore of the Bay of Gdańsk – Southern Baltic) the regular aeropalynological investigations started in 1994.

All five cities are surrounded by forest and farmland areas which provide suitable media for spore production. On the outskirts of Zakopane there are more meadow areas than farming lands. In Poznań, Warszawa and Ostrowiec Świętokrzyski mean annual precipitation is relatively low: 500 mm, 500 mm, 550–650 mm respectively. In Kraków (700–750 mm) and Zakopane (900–1300 mm) mean annual precipitation is higher. Vegetation seasons in the cities differ in length: 210–220 days in Poznań, Warszawa and Ostrowiec Świętokrzyski, over 220 days in Kraków

and 180 days in Zakopane. For this study the non-viable, volumetric method has been employed using five Burkard 7 day recording spore traps with a flow rate of 10 L min^{-1} . All the traps were installed on roof tops in the centres of the cities at different heights above ground level: Zakopane – 10 m, Kraków – 20 m, Ostrowiec Świętokrzyski – 36 m, Warszawa – 16 m, Poznań – 34 m. The cause of the different sampling heights was technical. The choice of the sites depended on people who could operate the traps, and the availability of buildings, where traps could be placed. The counting of spores was included in the counting procedure of pollen grains. Airborne spores were sampled continuously, 12 months a year in 1995 and 1996. The Melinex tape used for catching spores was replaced every Tuesday at 8 a.m. and cut into segments corresponding to 24 h periods. 12 transverse bands on each slide were analysed. Results were expressed as the number of spores m^{-3} air/24 h. To indicate spore occurrence during a year in absolute

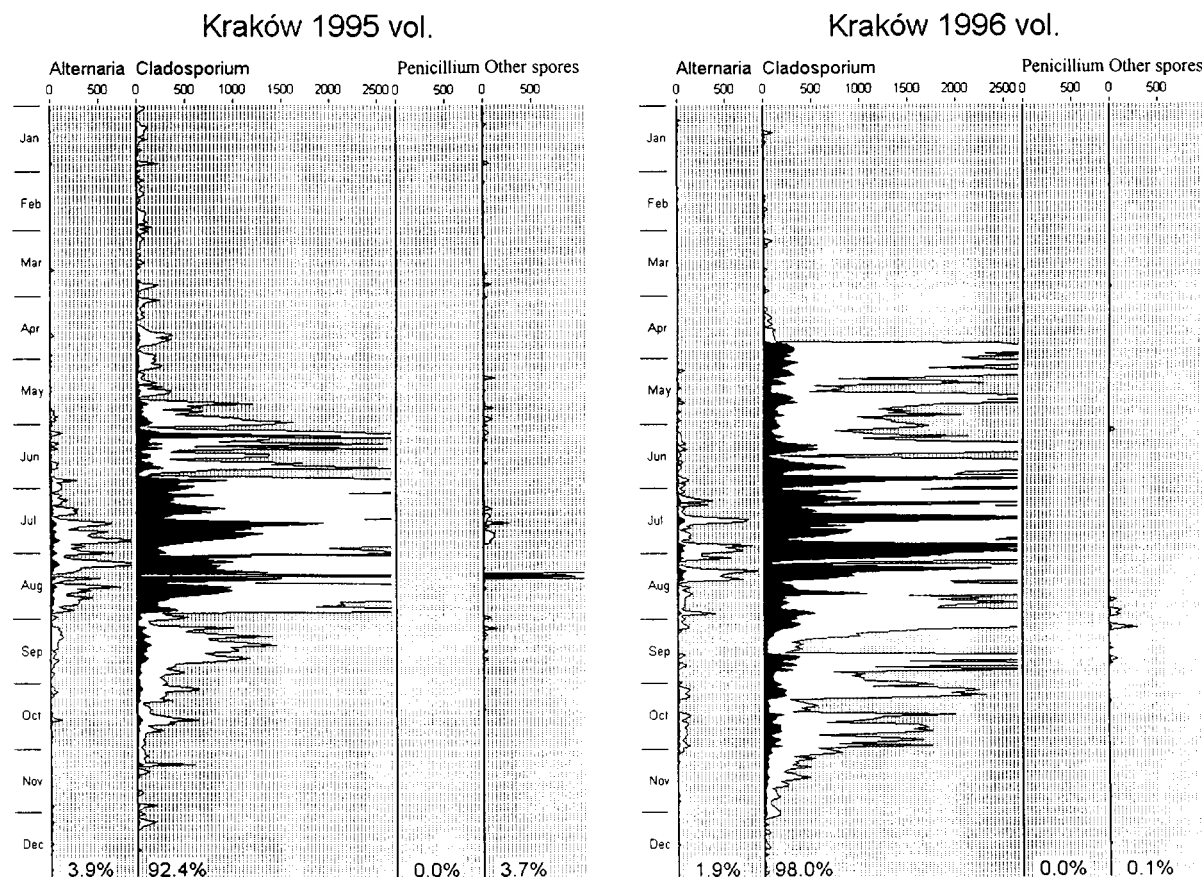


Figure 3. Absolute values of fungal spores in Kraków (percentage of taxa of annual sums of daily average concentrations) in 1995–1996. Black area: number of spores m^{-3} air, white area: 10-fold enlargement of absolute values.

values and to estimate percentage of the different types of spores in annual sums a computer programme (POLPAL) was employed.

3. Results and discussion

Absolute values of occurrence of spores of *Cladosporium* and *Alternaria* in the diagrams from Zakopane (Figure 2) and Kraków (Figure 3) show the highest concentrations of the spores in July and August in both years under study.

Abundant occurrence of *Cladosporium* spores was noticed from the beginning of June to the end of August.

Periods of continuous occurrence were recorded from the beginning of May to the middle of November. However, the spores were found at both sites all year round but in the remaining months of 1995 in low concentrations, and sporadically in 1996. Sporadic

occurrence reported in 1996 could be caused by the severe and long lasting winter with heavy snow cover. There was a sharp decrease in concentration of the spores in Zakopane and Kraków at the beginning of August in 1995. Periods of time of the highest, abundant and continuous occurrence of spores were distinguished on the basis of quantitative occurrence. Other fungal spores were of little significance in total spores counts.

In Ostrowiec Świętokrzyski the maximum incidence of *Cladosporium* spores was noticed in July, August and September (Figure 4) and in Poznań in June and July in 1995 (Figure 5). Regarding 1996, the highest concentrations were found at both sites in July and August. Abundant occurrence took place from the beginning of June to the end of October in 1995 and from the beginning of May to the end of October in 1996. Periods of continuous occurrence of the spores were observed from the middle of April to the middle of November, except at Poznań where the spores were

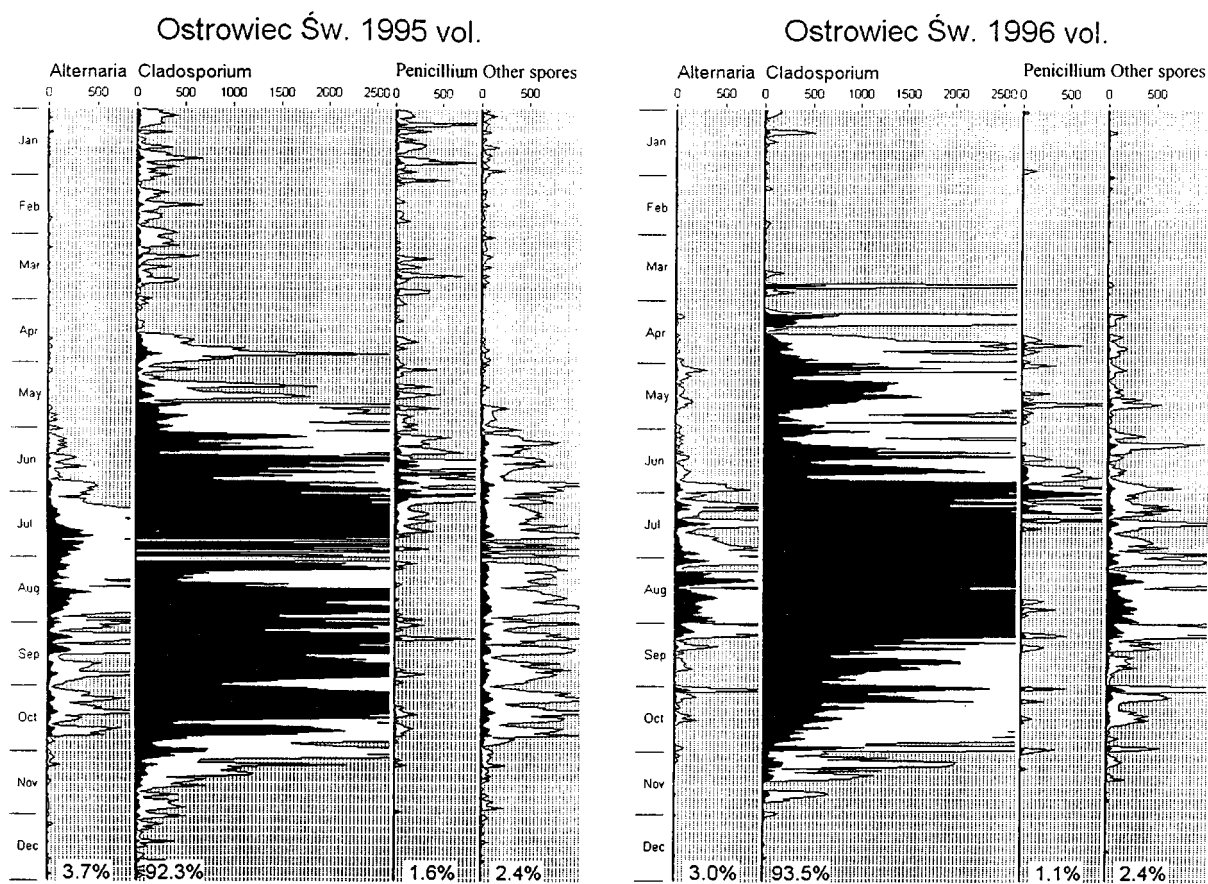


Figure 4. Absolute values of fungal spores in Ostrowiec Świętokrzyski (percentage of taxa of annual sums of daily average concentrations) in 1995–1996. Black area: number of spores m^{-3} air, white area: 10-fold enlargement of absolute values.

recorded in the air from the beginning of April to the end of November in 1996.

The presence of low concentrations of *Cladosporium* spores throughout the winter-spring time in 1995 and 1996 was similar to the observation at Zakopane and Kraków over the same period of time. At the beginning of August in 1995 a rapid decline was also observed in Ostrowiec Świętokrzyski and Poznań as at the other stations. Similarly the highest number of *Alternaria* spores was noticed in July and August.

The occurrence of *Penicillium* spores was recorded only at Ostrowiec Świętokrzyski, where they occurred from the beginning of January to the end of October in 1995 and from the middle of April to the end of October, with many interruptions, in 1996. Since the *Penicillium* spores are very small and hyaline there is possibility to take other spores for *Penicillium*, for example, *Aspergillus* spores. Other fungal spores were found in much greater concentrations in Poznań and

Warszawa than in Zakopane, Kraków and Ostrowiec Świętokrzyski – from the beginning of May to the end of October. During winter-spring they were recorded in low numbers.

Concentrations of *Cladosporium* spores at Warszawa were highest in June and July, 1995, and from the middle of June to the end of July, 1996 (Figure 6), while they were abundant from the beginning of May to the end of October, in 1995 and from the beginning of April to the end of October, 1996. During winter and spring *Cladosporium* spores were found in low concentrations in both years.

Alternaria spores occurrence in Warszawa was similar to that reported at the other stations.

Comparing the results obtained from the five stations, it is possible to distinguish three groups based on annual total spore counts. Lowest values were recorded at Zakopane and Kraków, followed by medium values at Warszawa and the highest values

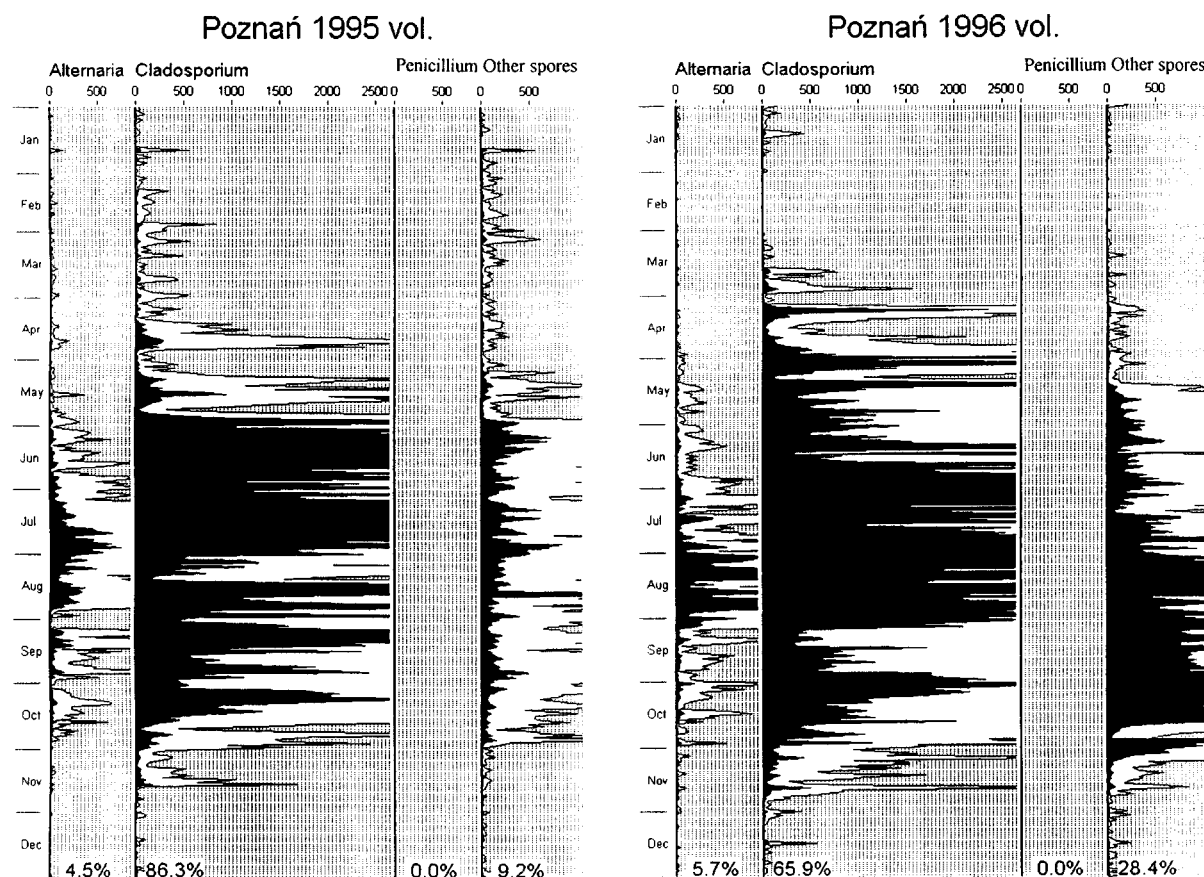


Figure 5. Absolute values of fungal spores in Poznań (percentage of taxa of annual sums of daily average concentrations) in 1995–1996. Black area: number of spores m^{-3} air, white area: 10-fold enlargement of absolute values.

at Ostrowiec Świętokrzyski and Poznań (Table 1). Usually, the highest number of spores is obtained when trapping is conducted at ground level or close to it (Kurkela, 1997). In this study, the spore traps were situated at different heights and the number of collected spores does not confirm this observation. The highest concentrations were recorded at Poznań and Ostrowiec Świętokrzyski where traps were placed at heights of 34 m and 36 m respectively. The lowest spore numbers were observed at Zakopane (10 m) and at Kraków (20 m). There were disparities in the annual spore counts between the 2 years monitored at four out of five stations, similarly considerable as those observed by Mitakakis et al. (1997) in Melbourne. At Poznań and Ostrowiec Świętokrzyski the inter-annual differences were smaller than in Zakopane and Kraków. Spore counts for 1995 in Zakopane were nearly twice as high as for 1996, and for 1995 in Kraków counts were nearly twice as low as for 1996.

Considering the periods of abundant *Cladosporium* spore occurrence there are two groups that can be distinguished:

1. At Zakopane and Kraków, where the peak periods were observed in June, July and August. Similar results were reported in Leiden (Nikkels et al., 1996) and in Sofia (Yankova and Peneva, 1996).
2. At Ostrowiec Świętokrzyski, Warszawa and Poznań where the peak periods were observed from the beginning of April, May or June to the end of October and were comparable with results obtained in Copenhagen (Larsen, 1981).

It is likely, that lower mean annual precipitation in Poznań, Warszawa and Ostrowiec Świętokrzyski than in Kraków and Zakopane would assist higher sporulation of fungi, as precipitation appears to be a limiting factor for *Cladosporium* sporulation and dispersal (Hjelmroos, 1993). Long vegetation seasons in Poznań, Warszawa and Ostrowiec Świętokrzyski could also affect high concentrations of spores. On the

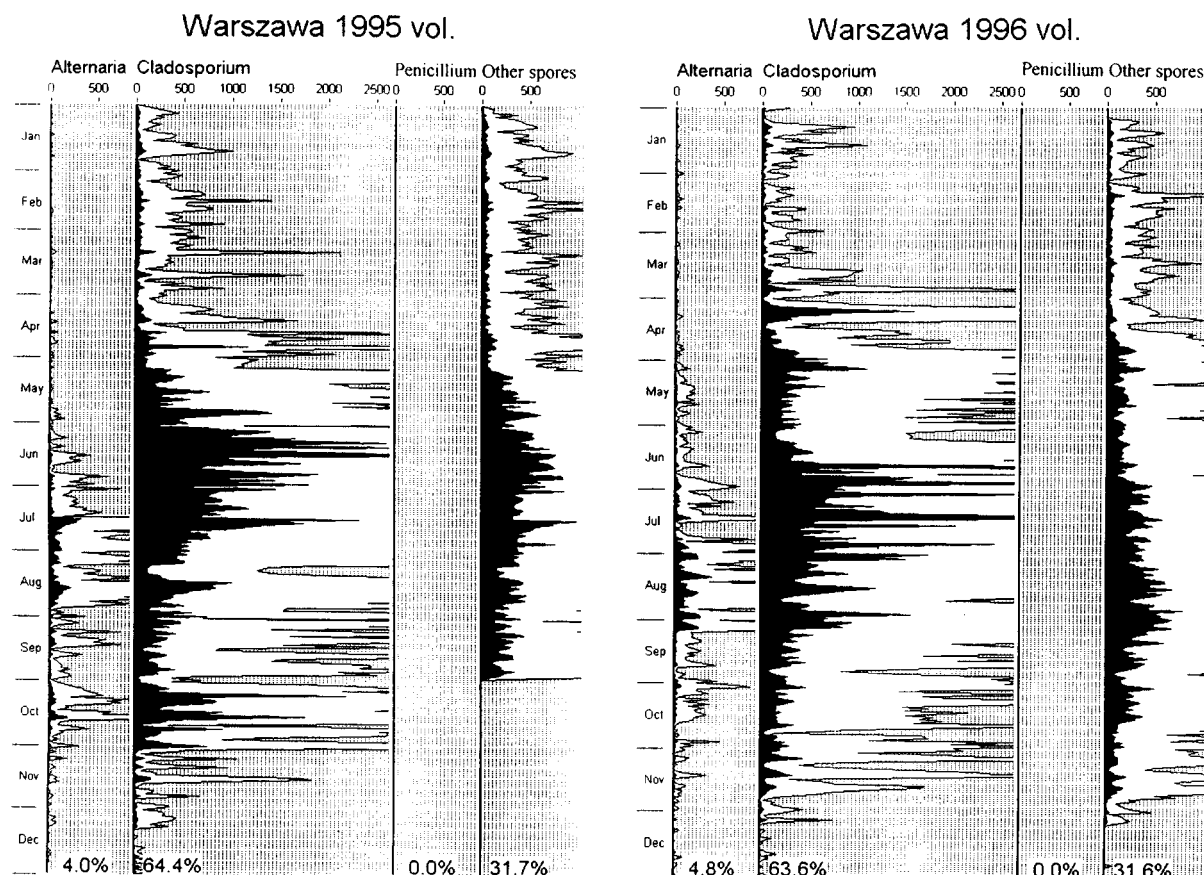


Figure 6. Absolute values of fungal spores in Warszawa (percentage of taxa of annual sums of daily average concentrations) in 1995–1996. Black area: number of spores m^{-3} air, white area: 10-fold enlargement of absolute values.

other hand, the longest vegetation season in Kraków did not result in comparatively high number of spores, probably because of higher mean annual precipitation in Kraków than in Poznań, Warszawa and Ostrowiec Świętokrzyski. The shortest vegetation season and the highest mean annual precipitation, with rainy spells mainly in summer, in Zakopane, could be the reason for low concentrations.

The monitoring of fungal spores in Poland revealed the summer as the most favourable season for *Cladosporium* and *Alternaria* occurrence, whereas in Cordoba (Infante and Dominguez, 1988) and on Sardinia (Cosentino et al., 1990) a decrease in spore concentrations was observed in summer. The summer decrease is thought to have been related to high temperature and lack of rain (Cosentino et al., 1990).

In Amman (Jordan) maximum spore counts were recorded in October, when spores of *Cladosporium* and *Alternaria* were most common in the air due to the warm, wet conditions (Shaheen, 1992).

Cladosporium belongs to the psychrophilic group of microorganisms which require low temperature, sometimes below 0°C , with an upper limit about 20°C and relative humidity about 70% for optimal growth (Herrero et al., 1996; Shaheen, 1992).

Not all airborne spores are viable as their viability depends on weather conditions. With regard to spore species, viability can differ considerably, for example, 80% of *Alternaria*, and 20–30% of *Cladosporium* spores are still viable after a certain period (Govi, 1992). High concentrations and long lasting presence of allergenic fungal spores in the air may cause and intensify clinical symptoms in people suffering from sensitivity and extend the period of presence of allergens in the atmosphere after the flowering season of vascular plants.

Table 1. Annual and monthly sums of daily average concentrations of *Cladosporium*, *Alternaria* and other fungal spores in 1995–1996 (spores m⁻³).

Taxon Month	Poznań		Ostrowiec Św.		Warszawa		Kraków		Zakopane	
	1995	1996	1995	1996	1995	1996	1995	1996	1995	1996
<i>Cladosporium</i>										
Jan	144	176	577	196	903	958	129	17	72	13
Feb	373	2	491	31	1377	599	109	10	71	1
Mar	494	666	609	740	1652	1844	131	34	109	60
Apr	2252	12262	1133	6734	3949	8999	316	2264	382	961
May	11539	45026	4259	23241	12395	11725	1009	5916	2175	1038
Jun	149591	79730	44486	51726	38797	25306	7058	14503	8087	11097
Jul	196175	198283	145407	158643	28635	35462	21352	37300	61713	26504
Aug	63420	151022	74953	191138	13091	19957	17738	19386	26538	15624
Sep	60126	31633	104941	58230	7788	10290	1985	4820	6813	3639
Oct	25548	34615	67237	23572	5310	6462	705	3789	4165	1804
Nov	770	3055	3007	1624	2087	3509	177	813	315	218
Dec	96	152	375	13	417	226	56	69	35	3
<i>Alternaria</i>										
Jan	29	31	17	1	15	21	4	11	1	6
Feb	35	8	6	6	14	46	0	3	3	2
Mar	52	16	10	4	31	33	3	1	9	0
Apr	100	50	17	56	41	67	7	0	10	7
May	204	333	45	219	74	297	27	29	44	49
Jun	1201	835	504	399	404	539	114	103	129	49
Jul	8520	4152	5318	2284	2738	1558	868	701	1014	410
Aug	5911	24352	5027	8140	2421	4614	918	609	621	366
Sep	1959	1899	2279	903	681	1313	146	71	356	131
Oct	605	852	1002	351	1191	614	44	192	103	97
Nov	20	74	60	15	126	180	6	11	13	21
Dec	6	13	20	1	54	37	11	1	2	1
Other fungal spores										
Jan	136	61	133	18	1183	661	15	0	127	0
Feb	288	9	89	13	1472	1187	4	0	120	0
Mar	404	85	106	17	1690	1238	15	2	111	0
Apr	325	390	57	192	2309	2806	4	0	162	0
May	1638	3689	155	331	8172	5493	40	0	443	0
Jun	8720	9736	1354	689	16176	6135	20	0	1063	0
Jul	9685	15795	1724	1299	14626	10730	117	0	328	0
Aug	8917	54557	1865	5330	9525	14210	1786	39	66	6
Sep	4761	34467	1785	1282	7124	9480	31	62	12	6
Oct	2528	46630	1754	976	0	6741	3	2	0	0
Nov	116	3119	185	96	0	2699	0	1	0	1
Dec	112	164	38	3	0	95	0	1	0	0
Annual totals	566800	757939	471025	538513	186468	196131	54948	90760	115212	62114

4. Conclusions

1. *Cladosporium* spores were dominant at all the monitoring stations.
2. The highest *Cladosporium* and *Alternaria* spore concentrations were observed at all the stations in July and August, except at Warszawa in both years and Poznań in 1995 where the maximum of *Cladosporium* spores occurred in June and July, and at Ostrowiec Świętokrzyski in 1995 where the maximum was found in July, August and September.
3. Fungal spore concentrations in Zakopane and Kraków were significantly lower than those in Ostrowiec Świętokrzyski, Warszawa and Poznań.
4. Periods of abundant *Cladosporium* spore occurrence were different in these groups of stations.

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