

## CLADOSPORIUM SPORES IN THE AIR OF SZCZECIN

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### Abstract

Moulds are common aeroallergens and *Cladosporium* is considered to be the most prevalent of them. The objective of the studies was to determine the seasonal variation in concentrations of *Cladosporium* spores due to meteorological parameters. The meteorological parameters analysed were maximum air temperature, relative humidity, amount of precipitation and wind speed.

The greatest threat from *Cladosporium* allergens was posed from the middle of May (2004, 2006) and June (2005) till the middle of October (2005) and in the end of October (2004) till the middle of November (2006).

Statistically significant correlations were found among the *Cladosporium* spore count in the air and maximum air temperature in all the analysed seasons, and amount of precipitation only in one season. The spore count of *Cladosporium* was determined by weather conditions, especially by air temperature.

Key words: *Cladosporium*, airborne spores, meteorological factors, Western Pomerania, Poland

### INTRODUCTION

*Cladosporium* spores are reported to form a majority of airborne spores in the temperate zones (Davies 1969, Solomon 1978). *Cladosporium* species live as saprophytes or as parasites on many kinds of plants. Dry spores produced in excessive quantities can be transported over wide areas, even oceans. Recordings from all parts of the world show that with a few exceptions *Cladosporium* is the most frequently encountered mould in the air. Its temperature optimum ranges 18–28°C, but growth down to -6°C is also possible (Gravesen, 1979).

There is a great seasonal variation in the concentration of *Cladosporium* conidia in the air; the highest concentrations occur during the summer from June to September (Ainsworth, 1952; Hyde and Williams 1953; Ballero et al. 1984, Ebner et al. 1989; Halwagy, 1989).

Generally, conidial production and dispersal in *Cladosporium* depend on precipitation, temperature, and the amount of available growth medium. High atmospheric spore concentrations can develop only when dead plant material, e.g. deciduous trees, freshly cut branches or twigs, are present as a medium (Kurkela, 1974) or dense vegetation continuously provides suitable media for conidial production (Halwagy, 1989).

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 due to pollen grains of vascular plants (D'Amato and Spiekma, 1995).

The aim of the study was to analyse the *Cladosporium* season in Szczecin (western Poland) in 2004–2006 and to establish a relationship between meteorological conditions and the *Cladosporium* spore amounts.

### MATERIALS AND METHODS

The results of investigation are based on aerobiological monitoring performed in Szczecin in 2004–2006. The Lanzoni 7 Day Recording Trap was installed on the roof top in Szczecin city district Śródmieście, at the height of 21 m above ground level (52 m above sea level).

Meteorological data covering three years of study were provided by the Automatic Weather Station (Vaisala, Finland). The meteorological parameters taken into regard in the assessment of the effect of meteorological conditions on airborne fungal spores were as follows: daily level of precipitation, wind speed, relative humidity and air temperature.

The degree of correlation between particular meteorological parameters and the concentration of *Cladosporium* spores was described by the Pearson's correlation coefficient  $r$  (statistical error risk was estimated

at the significance level of 95%,  $\alpha = 0.05$ ) (O k t a b a , 1980).

The spore data were analysed to determine the start, end and duration of the season using the 90% method.

## RESULTS

Spores of *Cladosporium* were found in the air in Szczecin practically throughout the whole year, with the exception of periods when temperature drops below 0°C (usually January-February and sometimes December).

Spores of *Cladosporium* were recorded every day during the years 2004, 2005 and 2006. The concentration during the spore season ranged from 177 spores  $\times$  m<sup>-3</sup> on 23 May to the annual peak of 31098 spores  $\times$  m<sup>-3</sup> on 8 July in 2004, from 24 spores  $\times$  m<sup>-3</sup> on 6 July to the annual peak of 22 737 spores  $\times$  m<sup>-3</sup> on 28 July in 2005, and from 63 spores  $\times$  m<sup>-3</sup> on 17 June to the annual peak of 19 560 spores  $\times$  m<sup>-3</sup> on 6 August in 2006 (Fig. 1).

The lowest total number of sporomorphs (39 6063) was noted in 2006, while in the other seasons its values were markedly higher (Tab. 1). The highest maximum spore count was noted in 2005 and it was equal to 675286 spores  $\times$  m<sup>-3</sup> per 24 h (Tab. 1, Figs 1, 2).

During the three years analysed, the maximum *Cladosporium* spore count was noted more or less in the middle of the spore season. The differences (a few days in every year) were caused by weather conditions. The vegetation season in 2004 and 2006, in comparison with 2005, started later because of frosty winter and cold

spring. In 2005 the spring was dry and warm, and the spore season was the shortest and most intensive.

Based on the results of analysis of spore season duration, a conclusion may be drawn that shorter spore seasons are characterised by higher annual sums of sporomorphs.

Starting from the third decade of May and the second decade of June in 2006 to the first decade of October, the spore count was high in the air over Szczecin. In 2004 and 2005 the period in which the *Cladosporium* spore count exceeded the threshold value of 2800 spores  $\times$  m<sup>-3</sup> per 24 h in Szczecin lasted 78-79 days. In 2006 it was shorter and lasted only 43 days (Tab. 1).

In 2004 and 2005 climatic conditions were favourable for *Cladosporium* growth and dispersal. The annual total count for both years was over 62 0000 spores  $\cdot$  m<sup>-3</sup> which is ca. 40% higher than in 2006.

The growth, sporulation and dispersal of *Cladosporium* seem to be sensitive to changes in the climatic situation. In some of the seasons studied, the *Cladosporium* spore count was statistically significantly correlated with the weather factors analysed (Tab. 2).

In all the seasons, the *Cladosporium* spore count was positive and statistically significantly correlated with maximum air temperature. Only in one out of the three seasons studied, a positive and statistically significant correlation was noted between the *Cladosporium* spore count and rainfall (Tab. 2).

*Cladosporium* as dry airspora is favoured by high temperature. If the temperature rises above 18° C, the *Cladosporium* concentration increases.

Table 1  
Results of aerobiological study of *Cladosporium* spores counts.

Taxon		2004	2005	2006
Cladosporium	ss	19 V-28 X (163)	14 VI-11 X (120)	23 V-16XI (178)
	tn	628095	675286	396063
	max	31098	22737	19560
	tsc	79	78	43

ss – spore season established by the 90% method (with number of days),

tn – total number of *Cladosporium* spores collected in the spore season established by the 90% method,

max – maximum number of spores per 24 h, tsc – the number of days with spores count above 2800 spores in 1 m<sup>3</sup> threshold of spores count at which allergy symptoms develop (Rapijko et al. 2004).

Table 2  
Correlation coefficients between *Cladosporium* spores counts and meteorological factors.

Taxon	Years	Meteorological factors			
		Temperature max. (°C)	Rainfall (mm)	Wind speed max. (m/s)	Relative humidity (%)
Cladosporium	2004	0.2915*	0.1399	-0.0918	-0.0419
	2005	0.3711*	-0.0392	0.0653	-0.0586
	2006	0.3044*	0.1658*	0.0006	-0.0720

\* Correlation statistically significant (p<0.05).

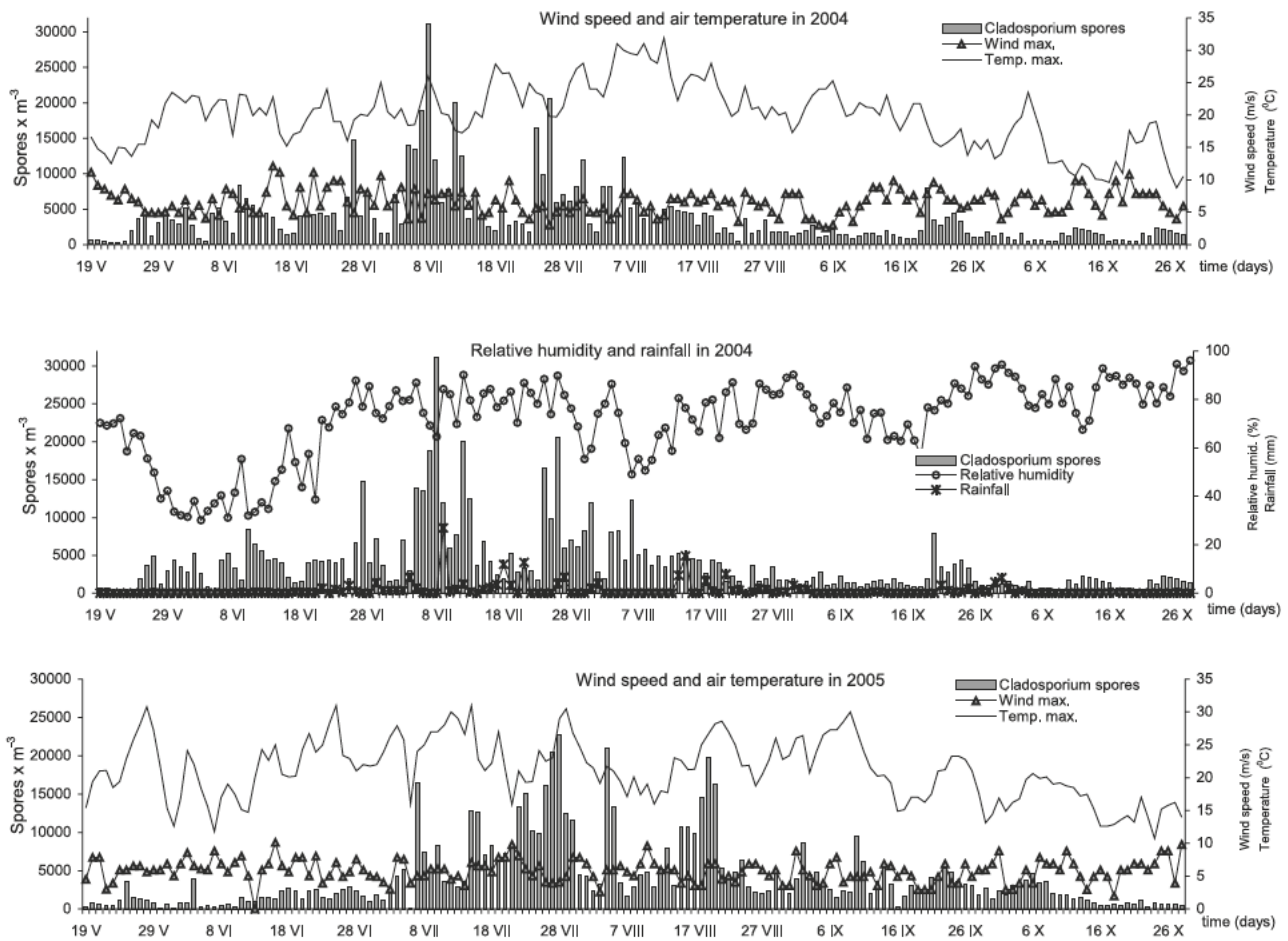
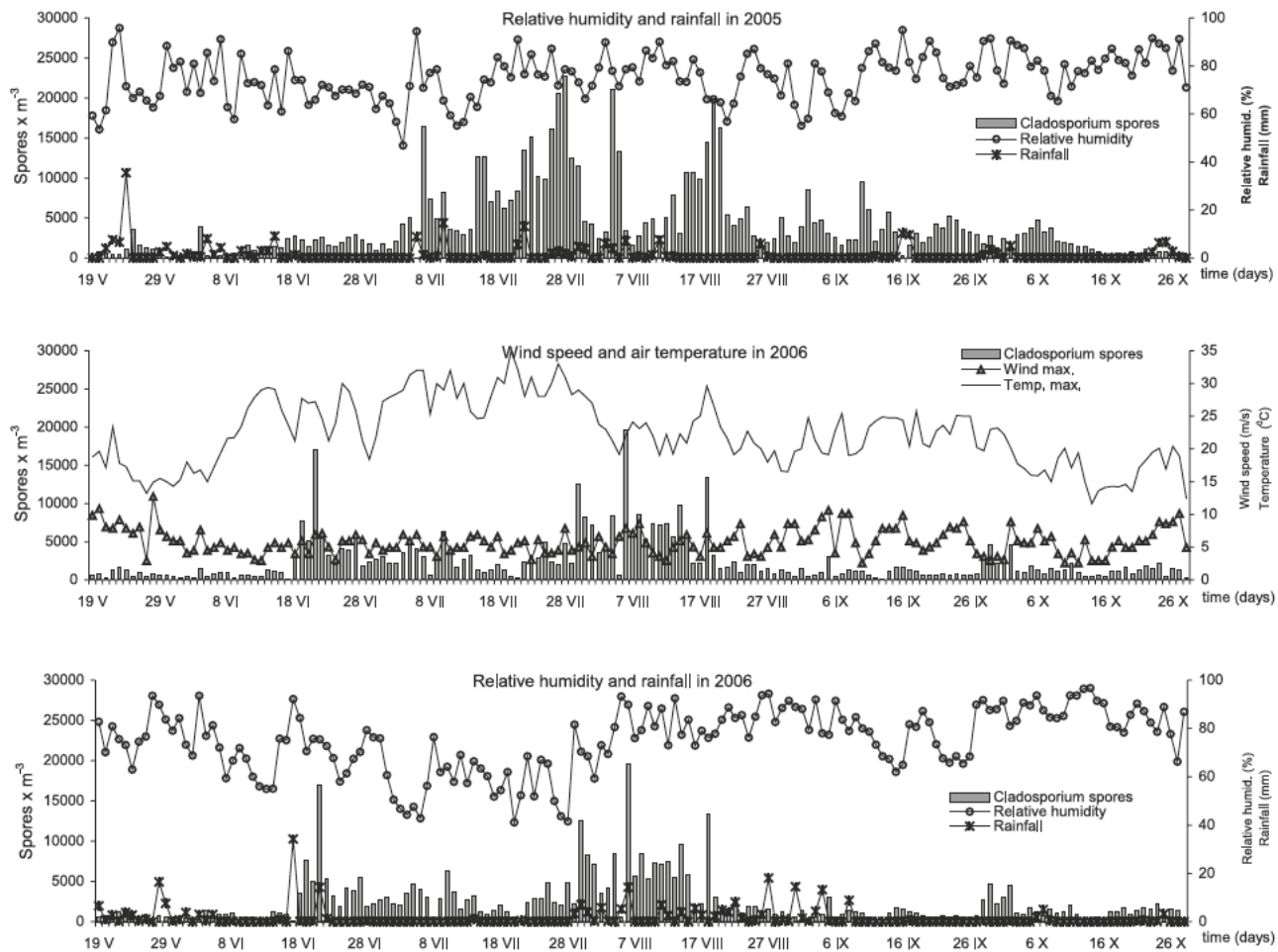


Fig. 1. Correlation among number of *Cladosporium* spores and relative humidity, rainfall, wind speed and air temperature in 2004, 2005 and 2006.



cd. Fig. 1.

## DISCUSSION

In Szczecin the highest number of *Cladosporium* spores was usually encountered during summer (July and August). Before and after that period (May and September), the spore concentration level was also high, but clearly lower than in summer.

The highest concentration of *Cladosporium* during summer was observed by Hjelmroos (1993) in Sweden and by Stępałska et al. (1999) in Poland.

The contrary occurrence was noted in Spain (Infante and Domínguez, 1988) and on Sardinia (Cosentino et al. 1990), where a decrease in spore concentration was observed during summer. This situation was associated with the lack of rain and very high air temperature (Cosentino et al. 1990). In Jordan spores of *Cladosporium* are the most common in the air due to the wet and warm season and maximum spore counts is noted in October (Shaneen, 1992).

In Szczecin the daily *Cladosporium* spore concentration has a positive, significant correlation with maximum temperature. The same correlation was noted in southern Poland (Stępałska and Wołek, 2005), Finland (Kurkela, 1997), Sweden (Hjelmroos, 1993), Spain (Fernandez et al. 1998) and New Zealand (Hasnain, 1993). Hasnain (1993) also reported the strongest correlation between the *Cladosporium* spore count and maximum day temperature in comparison with concentrations of other airborne fungal spores. Greenburg et al. (1964, 1966) considered that in some cases a mere change in ambient air temperature can provoke asthma symptoms in some patients.

The *Cladosporium* spore count was positive and statistically significantly correlated with rainfall only in one analysed season (2006).

A slight correlation between precipitation and the number of *Cladosporium* spores was observed in Finland by Kurkela (1997). Only in one season, rain

had a significant correlation with the number of spores counted 14 hours later.

Hjelmroos (1993) noted that the increase of atmospheric concentrations after the rainfall is generally long lasting, with the peak observed some hours after the rain. Mitakakis et al. (1997) reported a negative correlation with rain for *Cladosporium*.

During the analysed seasons, the correlation between the *Cladosporium* spore concentration and wind speed did not show a statistically significant correlation. The same results were noted by Levetin and Dorsey (2006), Hasnain (1993), Lopez and Salvaggio (1983).

The wind speed was clearly associated with spore dispersal in Finland (Kurkela, 1997). The long distance dispersal of spores depends on wind conditions, but the detachment of spores dispersed in dry conditions is also strongly influenced by wind (Malliah and Rao, 1982).

Similar results occurred regarding relative humidity in Szczecin, 2004-2006. Kurkela (1997), Stępańska and Wołek (2005) found a negative correlation between *Cladosporium* spore and relative humidity. During a rainy period, the level of spore concentration was low. Fernandez et al. (1998) reported that relative humidity, coupled with minimum temperature, was a factor affecting spore release. Hasnain (1993) did not observe any influence of relative humidity on *Cladosporium* spore concentration, contrary to other ascospores.

The high concentration and long lasting presence of *Cladosporium* 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.

The presented results reflect the necessity of widening the spectrum of factors, e.g. weather variables, which may determine the level of spore concentrations.

## CONCLUSIONS

- The higher *Cladosporium* spore concentration in Szczecin occurred in summer with peak periods in July (2004, 2005) and August (2006), and from June to October its concentration exceeded threshold values provoking allergy symptoms.

- The analysis of duration and dynamics of the *Cladosporium* spore seasons revealed that in the shorter spore seasons the annual sums of sporomorphs were high, while in the longer spore seasons these sums were lower.

- During all the seasons studied, the spore count of *Cladosporium* was positively statistically significantly correlated with maximum air temperature. A positive statistically significant correlation was also observed regarding rainfall during one spore season studied.

- The *Cladosporium* spores count in the air of Szczecin did not show a tendency to increase or decrease; however, this observation needs to be confirmed by long-term studies.

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## Zarodniki rodzaju *Cladosporium* w powietrzu Szczecina

### Streszczenie

Celem pracy jest analiza sezonu rodzaju *Cladosporium* w Szczecinie w latach 2004-2006 i ustalenie powiązania pomiędzy czynnikami meteorologicznymi a koncentracją zarodników. Podczas trzech sezonów przeanalizowano korelację pomiędzy stężeniem zarodników *Cladosporium* a maksymalną temperaturą powietrza, wilgotnością względną, opadem i prędkością wiatru za pomocą metody wolumetrycznej. Czas trwania sezonu wyznaczono metodą 90%. W ciągu trzech lat obserwacji najniższą dobową koncentrację zarodników *Cladosporium* zanotowano w 2006 roku z maksymalnym stężeniem wynoszącym 19560 zarodników na metr sześcienny. Najwyższa koncentracja wystąpiła w 2004 a stężenie dobowe wyniosło wtedy 31098 zarodników na metr sześcienny.

Objawy uczulenia alergenami *Cladosporium* u osób wrażliwych występują przy stężeniu 2800 zarodników na metr sześcienny. Stężenia przekraczające wartości progowe notowane były w trzecim tygodniu maja (dla lat 2004 i 2005) i w czerwcu (2006) do połowy października (dla roku 2005), końca października (2004) i do połowy listopada (2006).

Statystycznie istotna korelacja wystąpiła pomiędzy stężeniem zarodników *Cladosporium* a temperaturą maksymalną i w roku 2006 z opadami.