

Airborne *Alternaria* and *Cladosporium* species and relationship with meteorological conditions in Eskisehir City, Turkey

Ismuhan Potoglu Erkara · Ahmet Asan ·
Veysel Yilmaz · Sevil Pehlivan ·
Suzan Sarica Okten

Received: 21 March 2007 / Accepted: 28 August 2007
© Springer Science + Business Media B.V. 2007

Abstract *Alternaria* and *Cladosporium*, known as the most allergenic spores were first collected by means of Durham gravimetric sampler from Eskisehir atmosphere from January 1, 2000 to December 31, 2001. The daily, monthly and annual variations in spores/cm² of *Cladosporium* and *Alternaria* were recorded. During this period, a total of 10.231 spores belonging to *Cladosporium* and *Alternaria* genera were recorded. Of these spores, 5,103 were identified in 2000 and 5,128 in 2001. While 63.09% of the total spores were those of *Cladosporium*, 36.91% were of

Alternaria. Relationships between airborne fungal spore presence and meteorological conditions were statistically investigated. A Shapiro-Wilk test revealed that the airborne *Cladosporium* and *Alternaria* spores differed from a normal distribution. Thus, a Friedmann test was performed followed by a Pearson Correlation Analysis. The effects of rainfall, temperature and wind speed on *Cladosporium* and *Alternaria* numbers were non-significant according to the sites and months ($p>0.05$), but the effects of relative humidity on *Cladosporium* and *Alternaria* numbers were significant ($p<0.01$). Spore concentrations reached to their highest levels in May 2001.

I. P. Erkara
Faculty of Science and Art, Department of Biology,
Osmangazi University,
26480, Meselik,
Eskisehir, Turkey

A. Asan (✉) · S. S. Okten
Faculty of Arts and Sciences, Department of Biology,
Trakya University,
22030 Edirne, Turkey
e-mail: ahmetasan84@yahoo.com

V. Yilmaz
Faculty of Science and Art, Department of Statistics,
Osmangazi University,
26480, Meselik,
Eskisehir, Turkey

S. Pehlivan
Faculty of Science and Art, Department of Biology,
Gazi University,
06500 Ankara, Turkey

Keywords *Alternaria* · *Cladosporium* ·
Aeromycology · Airspora · Bioaerosol ·
Airborne fungi · Fungal spore concentration

Introduction

Airspora of several species of molds are known to induce numerous human diseases such as chronic bronchitis, asthma, fungal allergies and hypersensitivity pneumonitis. Tilak (1991) estimated that the between 2 and 30 % of respiratory allergies are due to fungal spores, and cited *Alternaria* and *Cladosporium* as the leading allergens (Pepelnjak and Segvic 2003).

During the last decades, allergic diseases have been constantly increasing in incidence and preva-

lence and consequently an increasing attention was paid to aerobiological monitoring of airborne fungal spores in various parts of the world.

Owing to their ubiquitous presence in nature, fungal spores represent an inevitable allergen source and are included among the most important agents responsible for provoking allergic manifestations (Al-Doory et al. 1980; Gravesen 1981; Cosentino et al. 1995). Moulds are common aeroallergens and both *Cladosporium* Link and *Alternaria* Nées are considered to be the most prevalent of these aeroallergens (D'Amato et al. 1984; Asan et al. 2002; Buck and Levetin 1985).

Cladosporium species live, like *Alternaria*, as saprophytes or as parasites on many kinds of plants. *Cladosporium* was reported to be the most common airborne fungus in temperate zones (Solomon 1978). *Alternaria* also has a world wide distribution. Sporulation and spore dispersal depend on biological, climatic and physical processes (Sakiyan and Inceoglu 2003; Hjelmroos 1993; Asan et al. 2004).

There have been many investigations in various parts of the world to determine the presence and sources of allergenic fungal species and to evaluate their seasonal variations (Kramer et al. 1959; Palmas and Cosentino 1990; Johansen 1991; Wynn-Williams 1991; Hjelmroos 1993; Dames and Cadman 1994; Singh and Singh 1994; Barkai-Golan et al. 1997; Bass and Morgan 1997).

Contrary, few studies have been performed on airborne fungi in Turkish cities [Ankara (Pehlivan and Atalay 1994; Sakiyan and Inceoglu 2003), Antalya (Ince and Pehlivan 1991), Bursa (Bicakci et al. 2001), Edirne (Sen and Asan 2001; Sarica et al. 2002; Asan et al. 2002), Istanbul (Colakoglu 1996; Asan et al. 2003), Izmir (Ayata et al. 1991), Sivas (Pehlivan and Ozler 1999)] but it is apparent that *Cladosporium* and *Alternaria* are common to all these studies.

The first study on airborne spores in the atmosphere of Eskisehir was done by Atik and Tamer (1994). They found that the dominant air fungal microflora consist of *Cladosporium*, *Alternaria*, *Penicillium* and *Aspergillus* respectively. Harmanci et al. (2000) determined that *Cladosporium* spores caused allergic reactions in adult patients with asthma and/or rhinitis in Eskisehir; they also explained that *Cladosporium* was the commonest cause. More recently, Asan et al. (2004) studied airborne fungi and Actinomycetes concentrations in the air of Eskisehir City. However, since the city is

undergoing a continuous developmental process the population and industrial activities are increasing in mentioned city.

The airspora concentrations of outdoor environments depend on numerous factor including; time of day, meteorological factors, seasonal climatic factors, and type of vegetation (Pepeljnjak and Segvic 2003).

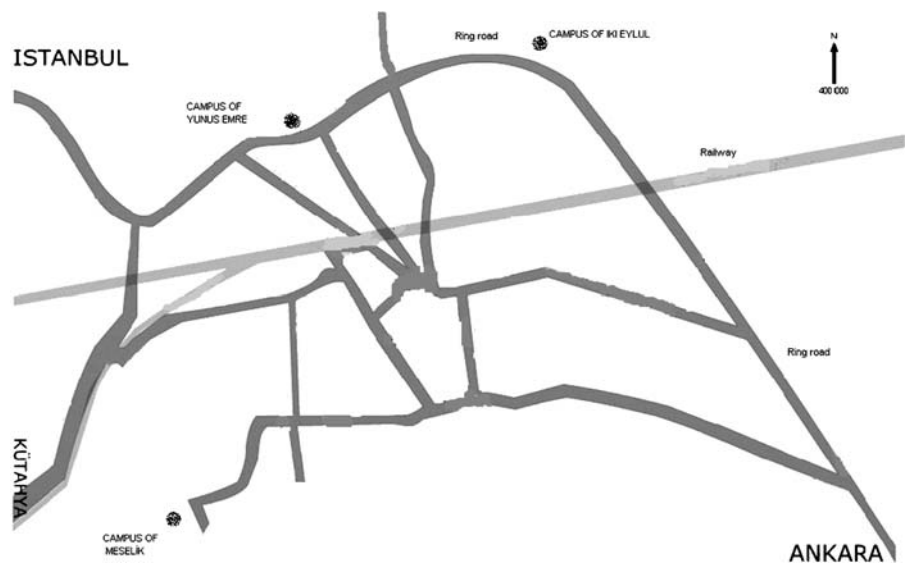
Therefore, the aim of our study was to determine the *Cladosporium* and *Alternaria* spores of the outdoor, environment in Eskisehir, with special respect to their relationships with climatic conditions and their seasonal changes.

Materials and methods

Sampling sites and vegetation Eskisehir is situated at 39°06' and 40°09'N, 29°58' and 32°04'E Northwest of Turkey (Fig. 1) at an altitude of 788 m. above sea level. Eskisehir has a Mediterranean, Irano-Turanien vegetation and a generally Mediterranean climate.

The concentrations of airborne *Cladosporium* and *Alternaria* spores from three urban areas in Eskisehir city, Turkey (Osmangazi University Meselik Campus; Anadolu University Yunus Emre Campus; Anadolu University İki Eylül Campus; Fig. 1) were investigated. The first station can be considered as having rich flora; there are 240 plant species and 41 varieties. Asteraceae, Boraginaceae, Brassicaceae, Fabaceae, Lamiaceae, Pinaceae, Poaceae and Rosaceae families are very common; latitude: 39°48'N, longitude: 30°32'E, altitude: 845 m. There are 363 plant species at the second station where the Aceraceae, Asteraceae, Betulaceae, Cupressaceae, Fabaceae, Fagaceae, Lamiaceae, Moraceae, Oleaceae, Poaceae, Pinaceae, Ranunculaceae, Rosaceae, Salicaceae and Ulmaceae families are common; latitude: 39°47'N, longitude: 30°29'E, altitude: 819 m. The third station is in a residential area, but some plant species belonging to the, Apiaceae, Asteraceae, Boraginaceae, Brassicaceae, Caryophyllaceae, Convolvulaceae, Fabaceae, Linaceae, Lamiaceae, Malvaceae, Papaveraceae Pinaceae, Plantaginaceae, Poaceae, Ranunculaceae, Rosaceae and Scrophulariaceae families are common (Davis 1965–1985; Davis et al. 1988; Guner et al. 2000; Ocak and Ture 2001); latitude: 39°44'N, longitude: 30°29'E, altitude: 789 m. While the first station is located in the south of the city, the second and third stations are

Fig. 1 A map of Eskisehir city (Turkey) showing the province of Eskisehir. The research stations are: Osmangazi University Meselik Campus; Anadolu University Yunus Emre Campus; Anadolu University Iki Eylul Campus



located in the north. Distances between the research stations and a meteorological station were measured by GARMIN GPS 12 CX device (Global Positioning System; Made in Taiwan, under USA patent). This device was also used to measure the altitude of the research stations.

In addition to the natural vegetation of Eskisehir, the following species are frequently seen in parks, gardens and streets of the city: *Acacia* spp (Wattle), *Acer* spp (Maple), *Aesculus hippocastanum* (Common Horse Chestnut), *Ailanthus altissima* (Tree of Heaven), *Alnus glutinosa* (Common Alder), *Betula* spp (Birch), *Carpinus betulus* (Hornbeam), *Castanea sativa* (Chestnut), *Cedrus libani* (Cedar of Lebanon), *Cercis siliquastrum* (Judas Tree), *Cornus mas* (Cornus), *Corylus* spp (Hazelnut), *Cupressus sempervirens* (Italian Cypress), *Eleagnus angustifolia* (Oleaster), *Fagus orientalis* (Oriental Beech), *Fraxinus excelsior* (Common Ash), *Forsytia* spp, *Juglans regia* (Walnut), *Juniperus* spp (Juniper), *Ligustrum vulgare* (Common Privet), *Lonicera* spp (Honeysuckle), *Morus alba* (White Mulberry), *Olea europea* (Olive Tree), *Platanus orientalis* (Oriental Plane), *Populus tremula* (Tremulous Poplar), *Prunus domestica* (Plum), *Quercus* spp (Oak), *Salix babylonica* (Chinese Weeping Willow), *Thuja* spp (Arborvitae), *Tilia tomentosa* (Silver Lime) and *Ulmus* spp (Linden).

Spore sampling and identification In this study, a gravimetric method and a Durham sampler were used (Anderson 1985; Bicakci et al. 2001). The Durham

sampler was placed at a height of 1.75 m above ground level in all three stations.

Slides placed on the Durham sampler were placed daily with new ones. Before exposure, the slides were covered with glycerine jelly mixed with basic fuchsin (Charpin et al. 1974). The slides were examined daily under the light microscope ($\times 400$). The numbers of spores found in the glass area (22×22 mm) were counted.

The identification and counting of spores were limited to genus levels. *Cladosporium* and *Alternaria* spores on the microscope were identified according to the descriptions of Ellis (1971). All slides identified in this study are kept at Osmangazi University, Department of Biology in Eskisehir (Turkey).

Meteorological data The meteorological data for Eskisehir were obtained from the records of Eskisehir Meteorological Service which is 9.2 km far away to the first station, 3.9 km to the second station, and 0.5 km to the third station. There have been continuous meteorological observations on Eskisehir since 1940. The annual average rainfall for the period 1940–2001 was 294.1 mm. and the average temperature for the same period was 10.8°C . The warmest month during this period was July with an average temperature of 21.5°C . The annual average humidity during this period was 67%. The predominant wind directions at the sampling site are west-northwesterly between March–October and east-southeasterly between November–February.

Statistical analyses A Shapiro-Wilk test revealed that the airborne *Cladosporium* and *Alternaria* spores differed from a normal distribution. Thus, a Friedmann test was performed, but since this test does not give any information about parameter relationships a third test, Pearson Correlation Analysis was performed (Shapiro and Francia 1972; Shapiro and Wilk 1965; Hair et al. 1995; Sharma 1996; Tabachnick and Fidell 1996).

Results

A total of 10,231 spores from *Cladosporium* and *Alternaria*, 5,103 in 2000 and 5,128 in 2001, were identified in the atmosphere of Eskisehir from January 1, 2000 to December 31, 2001. The annual spore numbers of both *Cladosporium* and *Alternaria* according to the studied stations were given in Table 1. Monthly variations of total spores of *Cladosporium* and *Alternaria* spores recorded in the atmosphere of Eskisehir during the years 2000–2001 are shown in Fig. 2 and Fig. 3. Concentrations of *Cladosporium* and *Alternaria* spores in the research stations for the period from January 1, 2000 to December 31, 2001 are shown Fig. 4.

The data obtained during the years 2000–2001 were pooled and presented accordingly.

Spore counts were low due to the temperature and wind speed in January and February. In March, there was a significant increase in spore numbers. This can also be correlated with higher temperatures and wind speed. Spore concentrations in April were different from those in March. There was a significant increase in spore concentrations in April. However, in the third week of April, the heavy rain, lower wind speed and temperature and higher humidity lowered the spore

amount. Also a small decline was seen in spore concentrations in April. This can be explained by the fact that the wind speed and the temperature were lower than in March. The highest amount of concentration of spores was in May. Lower rainfall and humidity and higher temperature and wind speed might have contributed to this increase (Figs. 5, 6, 7, 8). During June and July, when temperature continued to increase there was a decline in *Cladosporium* and *Alternaria*. Wind, rainfall and relative humidity were lower than in May. When the relative humidity decreases, spore concentrations decrease. In August, spore concentrations were found to increase. Also, temperature, wind speed and relative humidity levels were slightly higher than rainfall. The changes in wind speed and relative humidity had a big influence on the spore concentration, when the other climatic factors were optimal. Spore concentrations in September were very different from those in August. Very low temperatures and wind caused a decrease in spore concentrations during this month. In October, November and December mean temperatures were lower than in the previous months. Although humidity and wind were high enough, low temperatures caused a decrease in spore concentrations during these months.

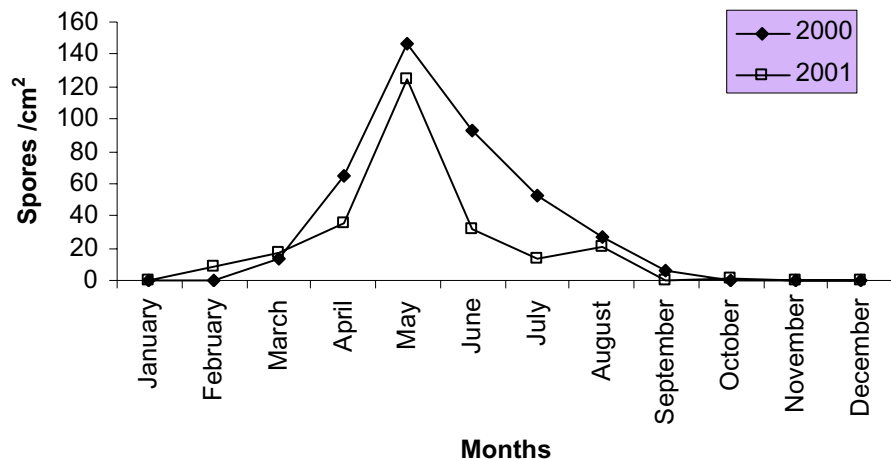
The peak period starts during the second half of April and lasts until the second week of June for *Cladosporium*. The highest weekly concentration was recorded in the second week of May. *Cladosporium* spore concentration decreased in the second week of June and until the third week of July. Then spore concentration increased in August.

Alternaria spore concentrations were maximal in Spring (April–May) and Summer (July–August). The initial seasonal peak occurred the second week of April and lasts until the second week of June for *Alternaria*. Maximum counts were recorded during the second week of May. *Cladosporium* spore

Table 1 Annual totals of daily spore counts

	<i>Cladosporium</i> spp				<i>Alternaria</i> spp			
	2000	2001	Total	Percent total	2000	2001	Total	Percent total
Meselik Campus	533	680	1,213	64,83	404	254	658	35,17
Yunus Emre Campus	967	1,014	1,981	60,53	506	786	1,292	39,47
İki Eylül Campus	1375	1,886	3,261	64,10	1,318	508	1,826	35,90
The whole city of Eskisehir	2,875	3,580	6,455	63,09	2,228	1,548	3,776	36,91

Fig. 2 Monthly variations in atmospheric *Cladosporium* spores in the atmosphere of Eskisehir from January 1, 2000 to December 31, 2001



concentration decreased in the second week of June and until the third week of July. Then spore concentration increased in August. In September, spore concentration decreased quickly. Medrelakuder (2003) and Fang et al. (2005; Gravesen 1981) also revealed a similar annual pattern for *Cladosporium* and *Alternaria*, respectively.

It has been shown by Shapiro-Wilk test that the rate of the microorganism present in the air is different from a normal distribution. A Friedman test made to indicate the variations between the data; *Cladosporium* spore numbers were varied in different location ($p < 0.01$), so are the *Alternaria* ($p < 0.05$; Tables 2 and 3).

According to Pearson's Correlation; there was a negative correlation between the amount of *Cladosporium* and the relative humidity in the first station

($r = -0.639$, $p = 0.025$); there was a negative correlation between the amount of *Alternaria* and the relative humidity the second station ($r = -0.703$, $p = 0.011$) and there was a negative correlation between the amount of *Alternaria* and the relative humidity in the third one ($r = -0.723$, $p = 0.008$; Table 4).

Discussion

The present study will contribute to our knowledge of airborne spores in Eskisehir. In the atmosphere of Eskisehir, *Cladosporium* spores in the campus of Iki Eylül, Anadolu University atmosphere were dominant due to the vegetation and geographical location of the city. Of the total, 6,455 (63.09 %) were *Cladosporium* and 3,776 (36.91 %) were *Alternaria* spores.

Fig. 3 Monthly variations in atmospheric *Alternaria* spores in the atmosphere of Eskisehir from January 1, 2000 to December 31, 2001

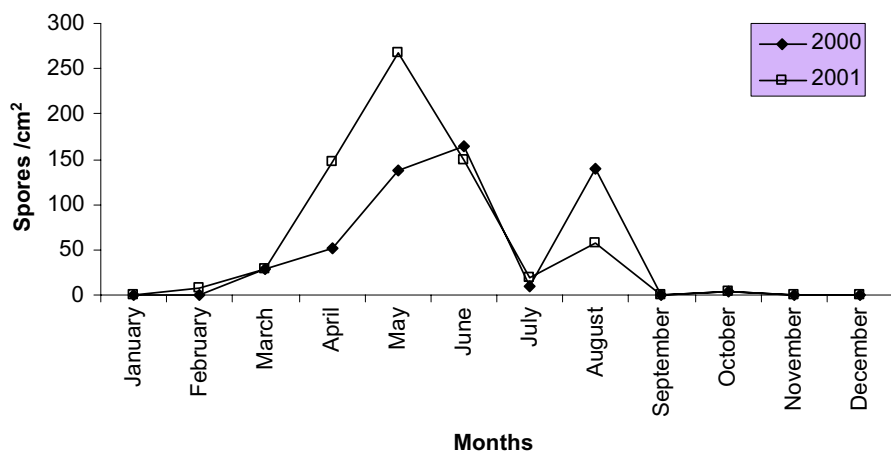
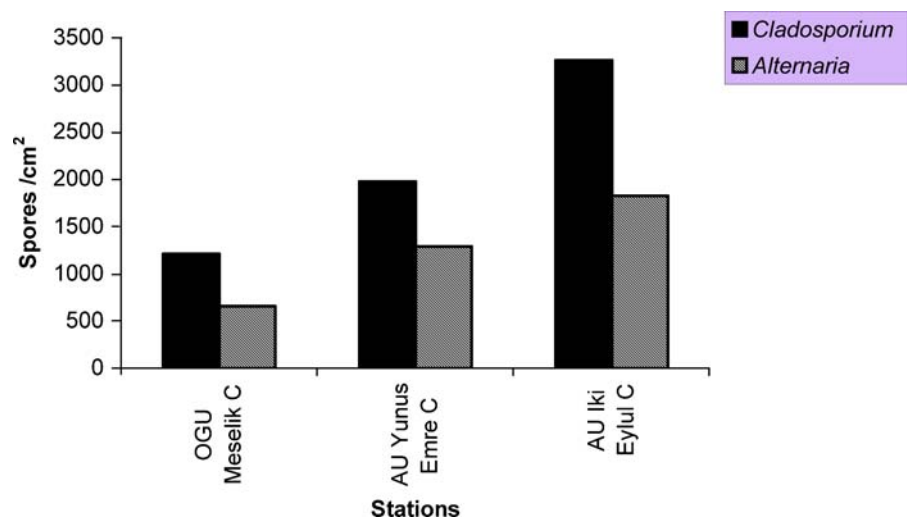


Fig. 4 Concentrations of *Cladosporium* and *Alternaria* spores in the research stations for the period from January 1, 2000 to December 31, 2001



During 2000–2001 *Cladosporium* and *Alternaria* spores were highly abundant in Eskisehir atmosphere; a total of 10,231 spores belonging to *Cladosporium* and *Alternaria* were recorded. *Cladosporium* spores of the third station were dominant due to the vegetation and geographical location of the city. *Cladosporium* and *Alternaria* spores form the majority of airborne spores in the air (Kramer et al. 1959; Bass and Morgan 1997; Asan et al. 2004).

In Stockholm, the annual totals for *Cladosporium* in 1980–1989 ranged from 220.000 to 300.000 spore/m³. In 1989, the average daily concentrations reached 450.000 spore/m³, which is 30% more than the above the 10-year average. The yearly totals of average daily

concentrations for *Alternaria* normally range from 1,000 to slightly over 2,000 spore/m³. In 1989 the yearly total of average daily counts was over 4,200 spore/m³, which is 50% higher than the 10-year average (Hjelmroos 1993).

Day to day variations in spore concentrations were chiefly due to the effects of rainfall. A significant increase in spore concentration after precipitation was determined (Kramer et al. 1959). Since temperature and rainfall were low, spore concentrations were very low. There was a significant correlation between temperature and total spore concentration (Palmas and Cosentino 1990; Hjelmroos 1993). When the relative humidity rises above and the wind is rather

Fig. 5 Monthly Temperature changes in Eskisehir's atmosphere from January 1, 2000 to December 31, 2001

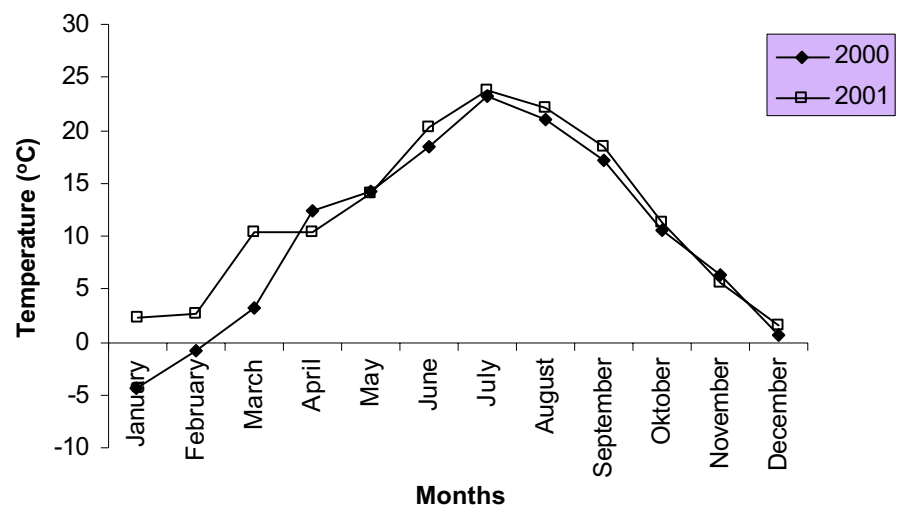
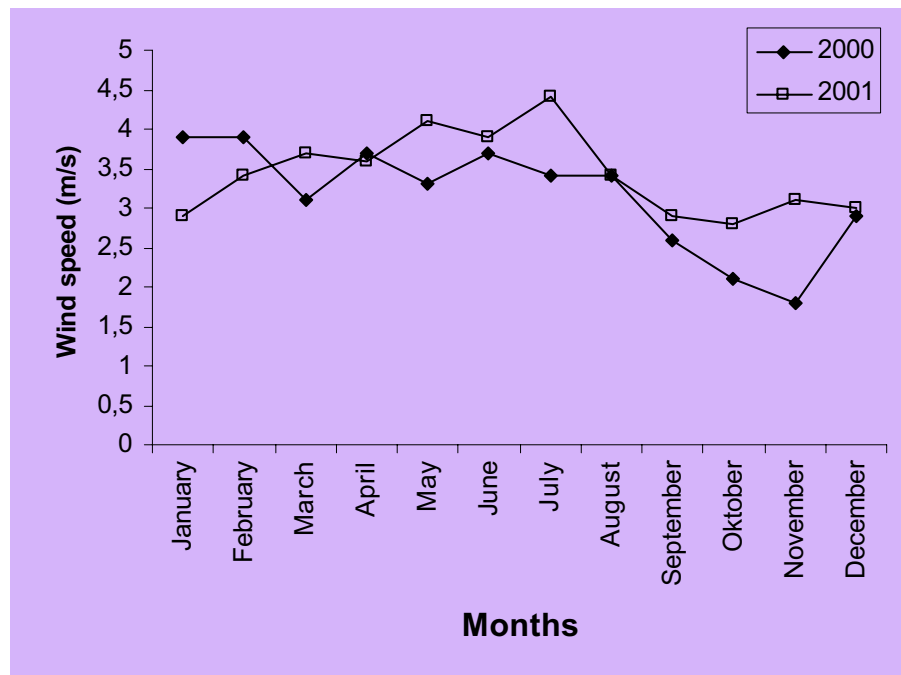


Fig. 6 Monthly Wind speed changes in Eskisehir's atmosphere from January 1, 2000 to December 31, 2001



strong, *Alternaria* concentrations increase. *Alternaria* seems to be more sensitive to variations in relative humidity than *Cladosporium* (Hjelmroos 1993). The highest *Cladosporium* spore concentration in Stockholm over a one year period occurred on July 29, 1986 when the spore/m³ value of air during one day was over 34.800. The highest daily *Alternaria* spore concentration during the period investigated was counted on August 7, 1984 (560; Hjelmroos 1993).

In conclusion, *Cladosporium* and *Alternaria* were affected by climatic factors such as temperature, rainfall, wind and relative humidity. Moreover, *Alternaria* seemed to be more sensitive to variations in relative humidity than *Cladosporium*.

Alternaria and *Cladosporium* spores are present throughout the two years in the atmosphere of Eskisehir, although they showed important seasonal variations. The highest concentrations of airborne

Fig. 7 Monthly Rainfall changes in Eskisehir's atmosphere from January 1, 2000 to December 31, 2001

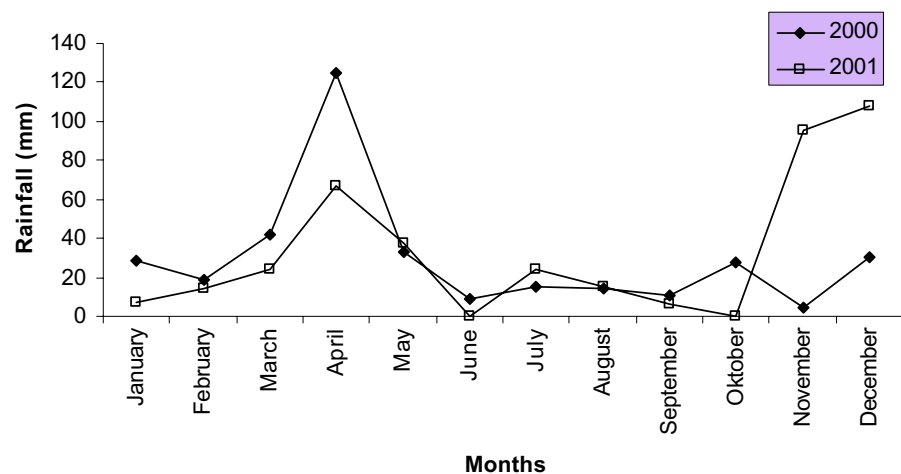
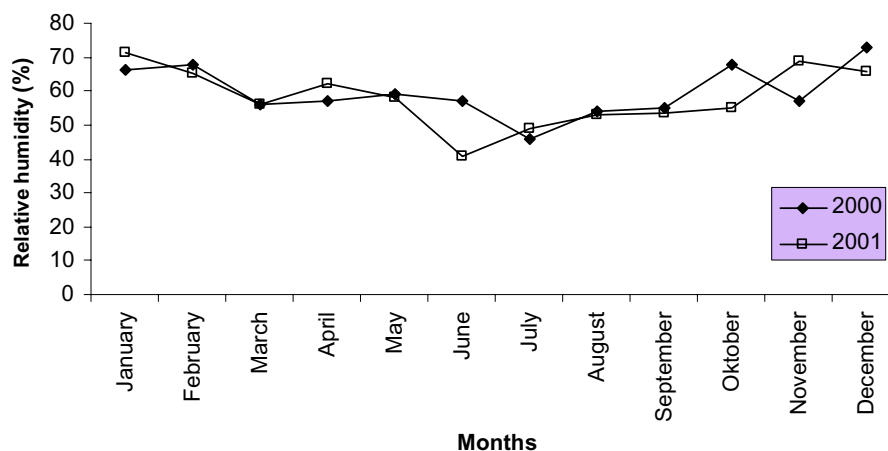


Fig. 8 Monthly Relative humidity changes in Eskisehir's atmosphere from January 1, 2000 to December 31, 2001



Cladosporium and *Alternaria* were recorded during Summer. Both spore types are present in lower levels in winter.

Even though they represented only a small proportion of the airborne particles present in the atmosphere, spores can be the cause of allergic responses in susceptible humans, and pollinosis (ocular rhinitis and asthma) is now a general public health problem. *Cladosporium* and *Alternaria* which could be detected in high numbers in the atmosphere of Eskisehir, may cause asthma and allergic rhinitis in susceptible humans (Solomon 1978; Gravesen 1981; Wynn-Williams 1991; Singh and Singh 1994; Pehlivan and Atalay 1994; Pehlivan and Ozler 1999; Harmanci et al. 2000).

The correlation between the monthly airborne spore counts and the monthly meteorological factors over the period January 2000–December 2001 clearly indicated that the spore concentration was affected by all meteorological parameters (wind speed, temperature, rainfall and humidity).

The higher numbers of spores in the air samples in 2001 is attributed to greater wind speed, lower rainfall and higher temperature in Spring than those in 2000.

The mean wind speed in Spring of 2001 was 4.1 m/s while it was 3.7 m/s in Spring of 2000. The mean temperature in Spring of 2001 was 14.1°C while it was 14.2°C in Spring of 2000. The mean humidity in Spring of 2001 was 62.3 % while it was 57.2% in Spring of 2000. Another reason for the greater amount of spore in 2001 is the higher precipitation between April 2000 and 2001 (125.1–66.8 mm). The lower spore concentration can be attributed to high rainfall and humidity and low temperature in April. High and continuous rainfall depressed spore dispersal. In addition, the lower wind speed slowed down spore dispersal in the atmosphere (Sakiyan and Inceoglu 2003).

We determined an increase in the total number of spores in 2001, which we attributed to the high amount of rainfall that Eskisehir had received for the past two years (2000–2001). Sunny and rainy weather has been reported to have a positive effect upon the increase in the total number of spores as humidity also increases with a rise in temperature. Heavy rain is known to hamper pollination, which results in a far slower growth of spores in the area affected (Sakiyan and Inceoglu 2003). A corresponding rise in the number of spore was recorded with a rise in both

Table 2 Friedman test, between *cladosporium* spores and the stations Friedman test statistics (*df*, degree of freedom)

Parameters	Values
<i>N</i>	12
Chi-square	14,000
<i>df</i>	2
<i>p</i>	<0.001

Table 3 Friedman test, between *alternaria* spores and the stations FriedmanTest statistics (*df*, degree of freedom)

Parameters	Values
<i>N</i>	12
Chi-square	9,256
<i>df</i>	2
<i>p</i>	<0.05

Table 4 Analysis of Pearson's correlation

		Temperature (°C)	Rainfall (mm)	Relative humidity (% RH)	Wind speed (m/s)
<i>Cladosporium</i> spp	Meselik Campus	$r=0.537$ ($p=0.072$)	$r=-0.002$ ($p=0.994$)	$r=-0.639^*$ ($p=0.025$)	$r=0.355$ ($p=0.258$)
	Yunus Emre Campus	$r=0.407$ ($p=0.189$)	$r=0.026$ ($p=0.935$)	$r=-0.504$ ($p=0.189$)	$r=0.259$ ($p=0.416$)
	Iki Eylul Campus	$r=0.486$ ($p=0.109$)	$r=-0.076$ ($p=0.109$)	$r=-0.511$ ($p=0.089$)	$r=0.194$ ($p=0.545$)
<i>Alternaria</i> spp	Meselik Campus	$r=0.516$ ($p=0.086$)	$r=0.216$ ($p=0.501$)	$r=-0.524$ ($p=0.08$)	$r=0.352$ ($p=0.262$)
	Yunus Emre Campus	$r=0.554$ ($p=0.062$)	$r=-0.008$ ($p=0.979$)	$r=-0.703^*$ ($p=0.011$)	$r=0.377$ ($p=0.228$)
	Iki Eylul Campus	$r=0.563$ ($p=0.057$)	$r=-0.011$ ($p=0.973$)	$r=-0.723^{**}$ ($p=0.008$)	$r=0.341$ ($p=0.278$)

* $p<0.05$, ** $p<0.01$

temperature and humidity on all the three campuses in the aftermath of rain (Figs. 2, 3, 5, 6, 7, and 8). Furthermore, periods with zero spore concentrations in the air can attributed to the fact that a heavy rain might be cleaning the air.

A comparison between the total numbers of spores on all the three stations showed Iki Eylul to have the highest and Meselik to have the lowest numbers of spores. This might be thought to be due to the fact that the dominant wind direction being west-north-westerly, the campus of Iki Eylul is a dense area with respect to spore dissemination.

Campuses of Yunus Emre and Iki Eylul are significant in that they are west-northwesterly situated in terms of exposure to the wind and dissemination of pollination from both nearby and far places. As to the campus of Meselik, it is south-southwesterly situated, with superficial and less severe wind currents, it has lower quantities of spores in comparison with the other two campuses.

We suggest that such studies as ours should be conducted routinely in consideration of changes in meteorological conditions, vegetation and cultivation areas. Some most important allergenic spores such as *Cladosporium* and *Alternaria* were also found in high concentrations in the study area. These spore types are responsible for many cases of pollinosis in the Mediterranean region and other parts of the world (Al-Doory et al. 1980; Gravesen 1981; D'Amato et al. 1984; Anderson 1985; Buck and Levettin 1985; Johansen 1991; Dames and Cadman 1994; Cosentino et al. 1995; Barkai-Golan et al. 1997).

The Friedmann test which was performed to reveal the relationship between *Cladosporium* an locations led us to conclude the spore numbers significantly differed among locations. And this means that, the location Yunus Emre affects somehow the spore presences of the *Cladosporium* and *Alternaria*. The vegetation present here might be the causal factor of this relationship.

In our research we observed *Cladosporium* and *Alternaria* to be in these amounts in the Eskisehir air for all months respectively. *Cladosporium* and *Alternaria* cause allergic reactions in people from April to September. In September, spore concentration decreased quickly. So, mentioned months are most likely to be high risk for mould sensitive patients.

The relationships between airborne fungal, *Cladosporium* Link and *Alternaria*, spore presences and meteorological conditions in the campuses of Meselik, Yunus Emre and Iki Eylul as well as for the city of Eskisehir presented in this paper may be useful for allergologist to establish a precise diagnosis and may help people suffering from allergic diseases.

The months during which *Alternaria* sp. and *Cladosporium* sp. spores can be found intensively vary between different regions due to climatological and vegetational differences. So, it is thought that determination of monthly concentrations and progresses of allergene airborne fungal spores in all regions will be beneficial in order to consider the regional differences for diagnosis and treatment of asthma and rhinitis cases that are sensitive to these allergenes. Since one of the leading treatment for

spore-sensitive cases is avoiding these allergens, these people should take some measurements during the periods when allergen spores are dense in atmosphere. Outdoor fungal spores are mainly present on decaying leaf materials, dung, straw, grass piles and in damp areas and they are spread into atmosphere during some activities performed by using grass cutting machines, rakes and plows. Therefore, sensitive people had better keep themselves away from such activities, keep their doors and windows closed and use filtered air conditions during risky months.

References

- Al-Doory, Y., Domson, J. E., Howard, W. A., & Sly, R. M. (1980). Airborne fungi and pollens of the Washington, DC Metropolitan Area. *Annals of Allergy*, 55, 794–801.
- Anderson, J. H. (1985). Allergenic airborne pollen and spores in Anchorage, Alaska. *Annals of Allergy*, 54, 390–399.
- Asan, A., Ilhan, S., Sen, B., Potoglu-Erkara, I., Filik, C., Cabuk, A. et al., (2004). Airborne fungal and Actinomyces concentrations in urban air of Eskisehir City (Turkey). *Indoor + Built Environment*, 13, 63–74.
- Asan, A., Kirgiz, T., Sen, B., Camur-Elipek, B., Guner, U., Guher, H. (2003). Isolation, identification and seasonal distribution of airborne and waterborne fungi in Terkos Lake (Istanbul-Turkey). *Journal of Basic Microbiology*, 43, 83–95.
- Asan, A., Sen, B., & Sarica, S. (2002). Airborne fungi in urban air of Edirne city (Turkey). *Biologia*, 57, 59–68.
- Atik, S., & Tamer, A. U. (1994). Eskisehir (merkez ilçe)'de mikrofungal hava kirliligi. *Ege Universitesi Fen Fakültesi Dergisi. Seri B Ek.*, 16, 227–238.
- Ayata, C., Coskun, S., & Okyay, T. (1991). Fungal flora of the air in several parts of Izmir according to months in 1989 and its importance regarding in the allergic diseases. *Türk Mikrobiyoloji Cemiyeti Dergisi*, 21, 219–226.
- Barkai-Golan, B. R., Frank, M., Kantor, D., Karadavid, R. & Toshner, D. (1997). Atmospheric fungi in Desert Town of Arad in the coastal plain of Israel. *Annals of Allergy*, 38, 270–274.
- Bass, D., & Morgan, G. (1997). A three year (1993–1995) calendar of pollen and *Alternaria* mould in the atmosphere of south western Sydney. *Grana*, 36, 293–300.
- Bicakci, A., Tatlidil, S., Canitez, Y., Malyer, H., & Sapan, N. (2001). Allergen *Alternaria* sp. and *Cladosporium* sp. spores in the atmosphere of Mustafakemalpasa (Bursa). *Arch Pulmonary*, 2, 69–72.
- Buck, P., & Levetin, E. (1985). Airborne pollen and mold spores in a subalpine environment. *Annals of Allergy*, 55, 794–801.
- Charpin, J., Suriyanch, R., & Frankland, A. W. (1974). *Atlas of European Allergenic Pollens*. Paris: Sandoz Editions.
- Colakoglu, G. (1996). Fungal spore concentrations in the atmosphere at the Anatolia Quarter of Istanbul, Turkey. *Journal of Basic Microbiology*, 36, 155–162.
- Cosentino, S., Fadda, M. E., & Palmas, F. (1995). Pollen and mold in mold allergy in southern Sardinia (Italy) comparison of skin-test frequencies and air sampling data. *Grana*, 34, 338–344.
- D'amato, G., Stanziola, A. G., Cocco, G., & Melilo, G. (1984). Mold allergy: A three year investigation (1980–1982) of the airborne fungal spores in Naples, Italy. *Annals of Allergy*, 52, 363–367.
- Dames, J. F., & Cadman, A. (1994). Airspora of Durban: A sub-tropical, coastal South African city. II. Fungal spore component. *Grana*, 33, 346–348.
- Davis, P. H. (Ed.) (1965–1985). *Flora of Turkey and The East Aegean Islands, Vol. 1–9*. Edinburgh: Edinburgh University Press.
- Davis, P. H., Mill, R. R., & Tan, K. (Eds.) (1988). *Flora of Turkey and The East Aegean Islands (Supplement). Vol. 10*. Edinburgh: Edinburgh University Press.
- Ellis, M. B. (1971). *Dematiaceous hyphomycetes*. England: Commonwealth Mycological Institute.
- Fang, Z., Ouyang, Z., Hu, L., Wang, X., Zheng, H., & Lin, X. (2005). Culturable airborne fungi in outdoor environments in Beijing, China. *Science of the Total Environment*, 350 (1–3), 47–58.
- Gravesen, S. (1981). On the connection between the occurrence of airborne microfungi and allergy symptoms. *Grana*, 20, 225–227.
- Guner A., Özhatay N., Ekim, T., & Baser, K. H. C. (Edt.) (2000). *Flora of Turkey and the East Aegean Islands. Vol. 11*. Edinburgh: Edinburgh University Press.
- Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). Multivariate data analyses with readings. (pp. 745). Englewood Cliffs, New Jersey: Prentice Hall.
- Harmanci, E., Metintas, M., & Erginel, S. (2000). Respiratory allergy to moulds among adults in Eskisehir Anatolia, Turkey. *Allergie et immunologie (Paris)*, 32, 49–51.
- Hjelmroos, M. (1993). Relationship between airborne fungal spore presence and weather variables, *Cladosporium* and *Alternaria*. *Grana*, 32, 40–47.
- Ince, A., & Pehlivan, S., (1991). A study on spores of *Alternaria* spp. in the atmosphere of Serik (Antalya). *Journal of Biology, Faculty of Science and Arts, Gazi University*, 2, 109–120.
- Johansen, S. (1991). Airborne pollen and spores on the Arctic island of Jan Mayen. *Grana*, 30, 373–379.
- Kramer, C. L., Paday, S. M. & Rogersen, C. T. (1959). Kansas aeromycology VIII: Phycomycetes. *Transactions of the Kansas Academy of Science*, 63, 19–23.
- Medrela-Kuder, E. (2003). Seasonal variations in the occurrence of culturable airborne fungi in outdoor and indoor air in Cracow. *International Biodeterioration & Biodegradation*, 52, 203–205.
- Ocak, A., & Ture, C. (2001). The flora of the Meselik campus of the Osmangazi University (Eskisehir-Turkey). *Ot Sistematik Botanik Dergisi*, 8, 19–46.
- Palmas, F., & Cosentino, S. (1990). Comparison between fungal airspore concentration two different sites in the South of Sardinia. *Grana*, 29, 87–95.

- Pehlivan, S., & Atalay, F. (1994). The investigation of house dust fungus spores, pollen grains and other biological materials in Ankara. *Journal of Faculty of Pharmacy of Gazi University*, 11, 143–150.
- Pehlivan, S., & Ozler, H. (1999). The investigation of *Alternaria* spp. spores in the atmosphere of Sivas city. 1st International Symposium on Protection of Natural Environment and Ehrami Karacam 23–25th September. Kutahya/TURKIYE.
- Pepeljnjak, S., & Segvic, M. (2003). Occurrence of fungi in air and on plants in vegetation of different climatic regions in Croatia. *Aerobiologia*, 19, 11–19.
- Sakiyan, N., & Inceoglu, O. (2003). Atmospheric concentrations of *Cladosporium* Link and *Alternaria* Nées spores in Ankara and the effects of meteorological factors. *Turkish Journal of Botany*, 27, 77–81.
- Sarica, S., Asan, A., Tatman-Otkun, M., & Ture, M. (2002). Monitoring indoor airborne fungi and bacteria in the different areas of Trakya University Hospital (Edirne-Turkey). *Indoor + Built Environment*, 11, 285–292.
- Sen, B., & Asan, A. (2001). Airborne fungi in vegetable growing areas of Edirne, Turkey. *Aerobiologia*, 17, 69–75.
- Shapiro, S. S., & Francia, R. S. (1972). Approximate analysis of variance test for normality. *Journal of American Statistical Association*, 67, 215–216.
- Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (Complete Samples). *Biometrika*, 52, 591–611.
- Sharma, S. (1996). *Applied multivariate techniques* (pp. 493). New York: Wiley.
- Singh, A., & Singh, A. B. (1994). Airborne fungi in a bakery and the prevalence of respiratory dysfunction among workers. *Grana*, 33, 349–358.
- Solomon, W. R. (1978). Aerobiology and inhalent allergens. 1. Pollens and fungi. In: E. Middleton, C. E. Reed, E. F. Ellis (Ed.), *Allergy: Principles and practice* (pp. 312–372). St. Louis: Mosby.
- Tabachnick, B. G., & Fidell, L. S. (1996). *Using multivariate statistics*. (p. 880). New York: Harper Collins College Publishers.
- Tilak, S. T. (1991). Fungal spores and allergy. *Journal of Palynology*, 27, 369–386.
- Wynn-Williams, D. D. (1991). Aerobiology and colonization in Antarctica – The BIOTAS Programme. *Grana*, 30, 380–393.