

Monitoring and assessment of airborne *Cladosporium* Link and *Alternaria* Nées spores in Sivrihisar (Eskisehir), Turkey

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Abstract The spores of *Cladosporium* spp. and *Alternaria* spp., commonly described as the most allergenic spores, were collected by means of Durham gravimetric sampler from the Sivrihisar (Eskisehir) atmosphere throughout 2005 to 2006. The weekly variations in spores/cm² of *Cladosporium* and *Alternaria* were recorded. During this period, a total of 6,198 spores belonging to *Cladosporium* spp. and *Alternaria* spp. were recorded. Of these spores, 2,969 were identified in 2005 and 3,229 in 2006. While 69.55% of the total spores were those of *Cladosporium* spp., 30.45% were *Alternaria* spp. Relationships between airborne fungal spore presence and weather conditions were examined statistically. A Shapiro–Wilk test revealed that the airborne spores of *Cladosporium* spp. and *Alternaria* spp. had a normal distribution. Following this, Chi-square test, *t* test and Pearson correlation analysis were performed. The effects of temperature and relative humidity on the spore

numbers of *Cladosporium* spp. and *Alternaria* spp. were significant according to the month in which they were collected ($p < 0.01$). The spore concentrations of each species reached to their highest levels in June 2006.

Keywords Aeromycology · Bioaerosol · Conidia · Fungal spores · Spore concentration

Introduction

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; Anderson 1985; Buck and Levetin 1985). 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 between 2 and 30% of respiratory allergies are due to fungal spores, and cited *Cladosporium* and *Alternaria* as the leading allergens (Pepeljnjak and Seugic 2003). During the last few decades, allergic diseases have been continually mounting in incidence and prevalence, with a consequential increase in the amount of

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attention being paid to the aerobiological monitoring of airborne fungal spores in various parts of the world.

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

There have been many investigations in various parts of the world to determine the presence and sources of allergenic species of fungi 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). Conversely, few studies have been performed on airborne fungi in Turkish cities, with only İzmir (Ayata et al. 1991), Antalya (Ince and Pehlivan 1991) İstanbul (Colakoglu 1996), Sivas (Pehlivan and Ozler 1999), Bursa (Bicakci et al. 2001), Edirne (Sen and Asan 2001; Asan et al. 2002; Sarica et al. 2002) and Ankara (Pehlivan and Atalay 1994; Sakiyan and Inceoglu 2003) represented so far, but it is apparent that *Cladosporium* spp. and *Alternaria* spp. are common to all these studies.

The first study on airborne spores in the atmosphere of Eskisehir was conducted by Atik and Tamer in 1994 (Atik and Tamer 1994). Harmanci et al later determined that *Cladosporium* spores caused allergic reactions in adult patients with asthma and/or rhinitis in Eskisehir; and further explained that *Cladosporium* spp. was the commonest cause (Harmanci et al. 2000). 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.

The airspora concentrations of outdoor environments depend on numerous factors, including; time of day, meteorological factors, seasonal climatic factors, and type of vegetation (Pepeljnjak and Seugic 2003). Therefore, the aim of our study was to determine the spores of *Cladosporium* spp. and *Alternaria* spp. in an outdoor environment in Sivrihisar (Eskisehir), with special respect to their relationships with climatic conditions and their seasonal changes.

Materials and methods

Sampling sites and vegetation

The research area, Sivrihisar (Eskisehir), is situated at 39°27'N, 31°32'E Northwest of Turkey (Fig. 1) at an altitude 1,070 m. Sivrihisar has a Mediterranean, Irano-Turanian vegetation and generally Mediterranean climate. Latitude: 39°26'42"N, Longitude: 31°32'36.8"E, Altitude: 1,071 m. Distances between the sampling point 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 station.

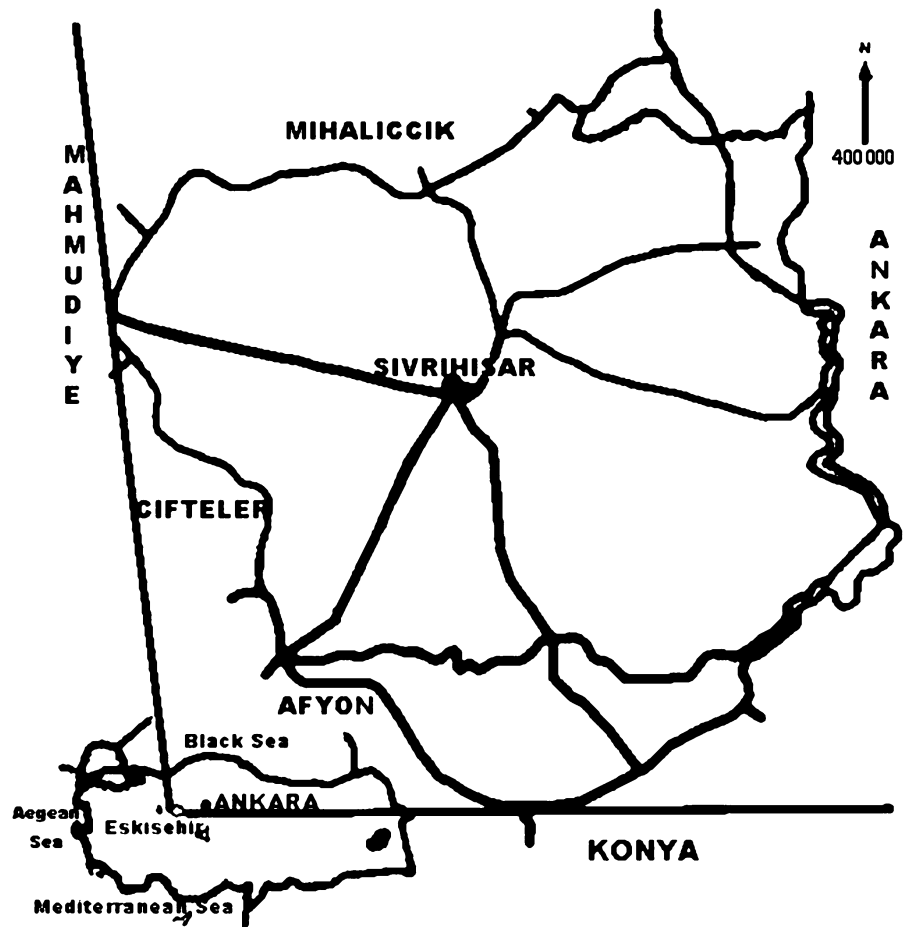
The research area has a rich flora; Pinaceae, Asteraceae, Fabaceae, Brassicaceae, Lamiaceae, Boraginaceae, Poaceae and Rosaceae families are very common (Davis 1965–1985; Davis et al. 1988; Güner et al. 2000; Ocak and Türe 2001).

In addition to the natural vegetation of Sivrihisar (Eskisehir), the following species are frequently seen in the parks, gardens and streets of the city: *Acacia* spp. (Wattle), *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), *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), *Lonicera* spp. (Honeysuckle), *Morus alba* (White Mulberry), *Platanus orientalis* (Oriental Plane), *Populus tremula* (Tremulous Poplar), *Prunus domestica* (Plum), *Quercus* spp. (Oak), *Salix babylonica* (Chinese Weeping Willow), *Thuja* spp. (Arboretum), *Tilia tomentosa* (Silver Lime) and *Ulmus* spp. (Linden; Türe 2002).

Spore sampling and identification

In this study, a gravimetric method was used (Anderson 1985; Bicakci et al. 2001). The Durham sampler was placed at a height of 1.75 m above ground level. Slides placed on the Durham sampler were replaced weekly with new ones. Prior to exposure, the slides were covered with glycerine jelly mixed with basic fuchsin (Charpin et al. 1974). The

Fig. 1 A map of Sivrihisar city (Turkey), showing the province of Sivrihisar



slides were examined weekly under a 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. The spores of *Cladosporium* spp. and *Alternaria* spp. on the microscope were identified according to the descriptions of Ellis (1971). All slides identified in this study are stored at Eskişehir Osmangazi University, Department of Biology in Eskişehir (Turkey).

Weather data

The weather data for Sivrihisar was obtained from the records of Sivrihisar Meteorological Service. There have been continuous meteorological observations on Sivrihisar since 1963. For the period 1963–2006, the annual average rainfall was 33.1 mm and the average temperature was 12.6°C for the same period. The

warmest month during this period was July with an average temperature of 21.8°C . The annual average humidity during this period was 69.3%. The predominant wind direction for the sampling site is south-southwesterly (Anonymous 2006).

Statistical analyses

A Shapiro–Wilk test was applied to determine distribution of the airborne spores of *Cladosporium* spp. and *Alternaria* spp. In addition, Chi-square test, *t* test and Pearson correlation analysis were performed (Ozdamar 2004).

Results and discussion

A total of 6,198 spores of *Cladosporium* spp. and *Alternaria* spp., 2,969 in 2005 and 3,229 in 2006,

Table 1 Annual and monthly totals of weekly spore counts and Pearson Chi-square tests

Months	Years	<i>Cladosporium</i> spp.	<i>Alternaria</i> spp.	Total	Chi-square tests
January	2005	18	7	25	$\chi^2=1.013, p=0.314$
	2006	29	6	35	
February	2005	3	3	6	$\chi^2=0.225, p=0.635$
	2006	2	1	3	
March	2005	13	6	19	$\chi^2=0.961, p=0.327$
	2006	30	24	54	
April	2005	75	7	82	$\chi^2=14.061, p=0.000$
	2006	137	57	194	
May	2005	302	51	353	$\chi^2=16.971, p=0.000$
	2006	420	147	567	
June	2005	656	163	819	$\chi^2=30.511, p=0.000$
	2006	909	404	1313	
July	2005	364	275	639	$\chi^2=2.060, p=0.151$
	2006	205	127	332	
August	2005	168	98	266	$\chi^2=0.151, p=0.698$
	2006	90	57	147	
September	2005	433	178	611	$\chi^2=13.157, p=0.000$
	2006	283	186	469	
October	2005	94	44	138	$\chi^2=0.992, p=0.319$
	2006	46	29	75	
November	2005	8	3	11	$\chi^2=0.232, p=0.630$
	2006	26	14	40	
December	2005	—	—	—	—
	2006	—	—	—	
2005		2,134	835	2,969	$\chi^2=14.502, p=0.000$
2006		2,177	1,052	3,229	
Total		4,311	1,887	6,198	
Percent		69.55	30.45	100.00	—

were identified in the atmosphere of Sivrihisar from January 2005 to December 2006. The annual spore numbers of both *Cladosporium* spp. and *Alternaria* spp. are given in Table 1. Monthly variations of *Cladosporium* spp. and *Alternaria* spp. spores recorded in the atmosphere of Sivrihisar during the

years 2005–2006 are shown in Figs. 2 and 3. The spore concentrations of *Cladosporium* spp. and *Alternaria* spp. obtained during the years 2005–2006 are shown Fig. 4. Of the full amount, 4,311 (69.55%) were *Cladosporium* spp. spores and 1,887 (30.45%) were *Alternaria* spp. spores. The spores of *Cladosporium*

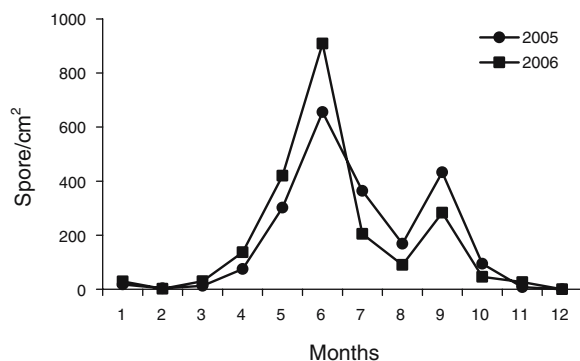
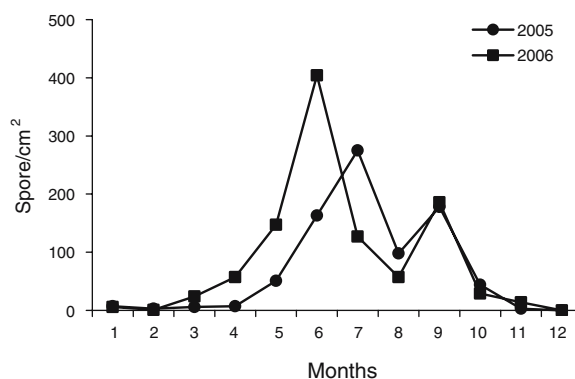
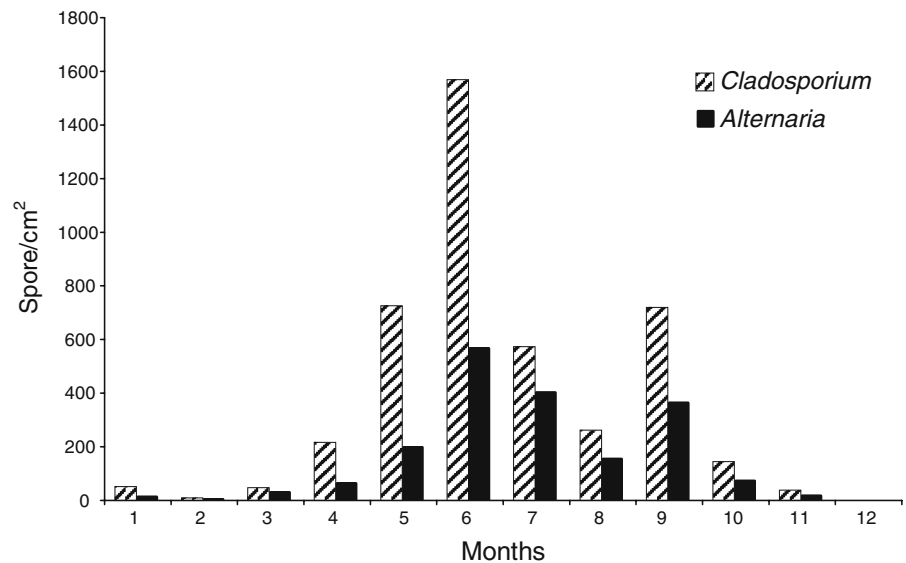
**Fig. 2** Monthly variations in atmospheric *Cladosporium* spores in the atmosphere of Sivrihisar throughout the 2 years**Fig. 3** Monthly variations in atmospheric *Alternaria* spp. spores in the atmosphere of Sivrihisar throughout the 2 years

Fig. 4 Monthly concentrations of *Cladosporium* spp. and *Alternaria* spp. spores throughout the 2 years



spp. were dominant due to the vegetation and geographical location of the city. In addition, *Cladosporium* spp. spores are lighter than *Alternaria* spp. spores and thus they readily overspread (Kramer et al. 1959; Bass and Morgan 1997; Asan et al. 2004). In several studies, it has been revealed that *Cladosporium* spp. and *Alternaria* spp. spores form the majority of airborne spores in the air, respectively. It has been reported that in Stockholm, the annual total spores for *Cladosporium*

spp. in 1980–1989 ranged from 220,000 to 300,000 spore/m³, for *Alternaria* normally range from 1,000 to slightly over 2,000 spore/m³ (Hjelmroos 1993).

The peak period starts during the second half of May and lasts until the second week of June for *Cladosporium*, and the second week of April and lasts until the second week of June for *Alternaria*. The highest weekly concentration for the spores of both species was recorded in the second week of June.

Fig. 5 Monthly temperature, wind speed, rainfall and relative humidity changes in the atmosphere of Sivrihisar throughout the 2 years

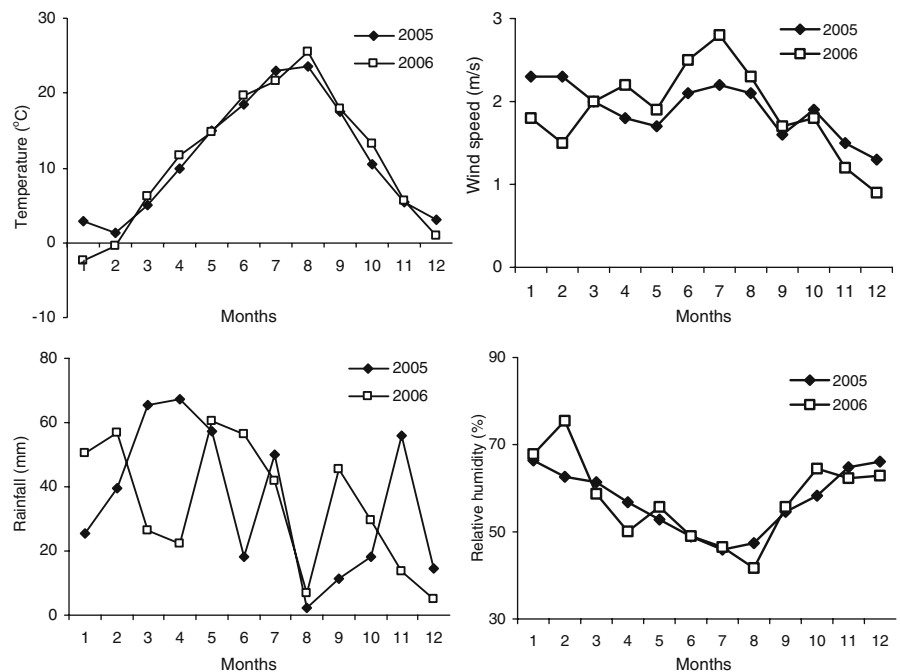


Table 2 Analysis of Pearson's correlation

	Years	Temperature (°C)	Rainfall (mm)	Relative humidity (% RH)	Wind speed (m/s)
<i>Cladosporium</i> spp.	2005	$r=0.846^{**}$ ($p=0.001$)	$r=-0.203$ ($p=0.527$)	$r=-0.825^{**}$ ($p=0.001$)	$r=0.137$ ($p=0.672$)
	2006	$r=0.755^{**}$ ($p=0.007$)	$r=0.273$ ($p=0.417$)	$r=-0.715^{*}$ ($p=0.013$)	$r=0.610^{*}$ ($p=0.046$)
<i>Alternaria</i> spp.	2005	$r=0.877^{**}$ ($p=0.000$)	$r=-0.466$ ($p=0.149$)	$r=-0.849^{**}$ ($p=0.001$)	$r=0.018$ ($p=0.957$)
	2006	$r=0.811^{**}$ ($p=0.002$)	$r=0.173$ ($p=0.611$)	$r=-0.749^{**}$ ($p=0.008$)	$r=0.557$ ($p=0.075$)

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

Spore concentrations decreased in the second week of July, until the third week of August. Day to day variations in spore concentrations are chiefly due to the effects of rainfall. Kramer et al. (1959) determined a significant increase in spore concentration after precipitation. When temperature and rainfall are low, spore concentrations are very low. There is also a significant correlation between temperature and total spore concentration (Palmas and Cosentino 1990; Hjelmroos 1993). When the relative humidity rises above a certain level and the wind is rather strong, *Alternaria* concentrations increase. *Alternaria* seems to be more sensitive to variations in relative humidity than *Cladosporium* (Hjelmroos 1993).

The spore concentrations of *Cladosporium* spp. and *Alternaria* spp. similarly varied monthly throughout the 2 years. In January and February, spore counts were low due to the temperature and wind speed. In March, there was a significant increase in spore numbers. This can also be correlated with higher temperatures and wind speed. In April and May, spore concentrations showed a significant increase in comparison with those in March. However, in the third week of April, the heavy rain, lower wind speed, temperature, and higher humidity lowered the spore

amount. The highest amount of concentration of spores was in June. Lower rainfall, humidity, higher temperature and wind speed might have contributed to this increase (Fig. 5). During July, when the temperature continued to increase, there was a decline in the number of *Cladosporium* spp. and *Alternaria* spp. spores, with wind, rainfall and relative humidity levels lower than those of May. It is known that when relative humidity decreases, spore concentrations decrease. Spore concentrations in August were very different from those in June. High temperatures and wind caused a decrease in spore concentrations during this month. In September, spore concentrations were found to increase. Here, temperature, wind speed and relative humidity levels were also slightly higher than rainfall. Changes in wind speed and relative humidity had a big influence on spore concentration, when other climatic factors were optimal. In October, November and December mean temperatures were lower than in the previous months. Although humidity and wind were sufficiently high, the low temperature caused a decrease in spore concentrations during these months. The correlation between the monthly airborne spore counts and the monthly meteorological factors over the period January 2005–December 2006 clearly

Table 3 *t* test analysis of weather conditions

Weather Conditions	Years	Mean	Standard Error Mean	T	P
Temperature (°C)	2005	11.308	2.309	0.184	0.858
	2006	11.192	2.651		
Rainfall (mm)	2005	35.408	6.657	0.101	0.921
	2006	34.567	5.772		
Relative humidity (% RH)	2005	57.167	2.111	-0.237	0.817
	2006	57.533	2.803		
Wind speed (m/s)	2005	1.900	0.094	0.138	0.892
	2006	1.883	0.154		

indicated that the spore concentration was affected by all meteorological parameters (wind speed, temperature, rainfall and humidity).

Alternaria and *Cladosporium* spores were present in the atmosphere of Sivrihisar throughout the 2 years, although they showed important seasonal variations. The highest concentrations of airborne *Cladosporium* and *Alternaria* were recorded during summer. Both spore types are present in lower levels in winter.

The higher numbers of spores in the air samples for 2006 is attributed to greater wind speed, lower rainfall and higher temperature in spring than those in 2005. The mean wind speed in spring 2006 was 2.2 m/s, compared with 1.8 m/s for spring 2005. The mean temperature in spring 2006 was 11.6°C, while it was 10.0°C in spring 2005. The mean humidity in spring 2006 was 55.7%, while it was 52.8% in spring 2005. Another reason for the greater amount of spores recorded in 2006 is the higher precipitation between May 2005 and 2006 (57.3–60.3 mm). Sunny and rainy weather has been reported to have a positive effect upon an 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 spores was recorded in the research area with a rise in both temperature and humidity following rain (Figs. 2, 3 and 5). Furthermore, periods with zero spore concentrations in the air can be attributed to the fact that a heavy rain may 'clean' the air.

A comparison between the total numbers of spores on the station showed *Cladosporium* to have the highest, and *Alternaria* to have the lowest numbers of spores. This might be considered to be due to the dominant wind's south–southwesterly direction, study area with respect to spore dissemination.

It has been shown by Shapiro–Wilk test that *Cladosporium* spp. and *Alternaria* spp. spores present in the air are a normal distribution. According to Chi-square test, *t* test and Pearson correlation analysis, the effects of temperature and relative humidity on the spore numbers of *Cladosporium* spp. and *Alternaria* spp. were significant according to the month ($p < 0.01$; Tables 1, 2, 3). The vegetation present here might be the causal factor of this relationship.

The annual total amount of fungal spores significantly differed in 2005 and 2006. This difference was

observed in April, May, June and September (Table 1). According to Pearson's correlation; there was a negative correlation between the amount of fungal spores and the relative humidity; while there was a positive correlation between the amount of fungal spores and the temperature (Table 2). It has been shown by *t* test that the weather conditions are no different in 2005 and 2006 (Table 3).

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*.

We suggest that such studies as ours should be conducted routinely in consideration of changes in meteorological conditions, vegetation and cultivation areas. Some of the 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 Levetin 1985; Johansen 1991; Dames and Cadman 1994; Cosentino et al. 1995; Barkai-Golan et al. 1997). In our research, we observed *Cladosporium* and *Alternaria* to be in these amounts in the Sivrihisar air for all months, respectively. *Cladosporium* and *Alternaria* cause allergic reactions in people from April to September. These months are most likely to be a high risk for mould sensitive patients.

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References

- Al-Doory, Y., Joanne Domson, J. F., Howard, W. A., & Sly, R. M. (1980). Airborne fungi and pollens of the Washington D.C. 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.
- Anonymous, (2006). Devlet Meteoroloji İşleri Genel Müdürlüğü, Sivrihisar Meteoroloji Müdürlüğü, Sivrihisar.
- Asan, A., İlhan, S., Şen, B., Potoglu Erkara, I., Filik, C., Cabuk, A., et al. (2004). Airborne fungal and actinomycetes concentrations in urban air of Eskisehir City (Turkey). *Indoor and Built Environment*, 13, 63–74.
- Asan, A., Şen, 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 ilce) de mikrofungal hava kirliliği. *Ege Universitesi Fen Fakültesi Dergisi Seri B*, 16, 227–238.
- Ayata, C., Coskun, S., & Okyay, T. (1991). Fungal flora of the air in several parts of İzmir 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 costal plain of Israil. *Annals of Allergy*, 38, 270–274.
- Bass, D., & Morgan, G. (1997). A three year (1993–1995) calender of pollen and *Alternaria* mould in the atmosphere of south western Sydney. *Grana*, 36, 293–300.
- Bicakci, A., Tatlıdil, S., Canitez, Y., Malyer, H., & Sapan, N. (2001). Allergen *Alternaria* sp. and *Cladosporium* sp. spores in the atmosphere of Mustafakemalpaşa (Bursa). *Archives of 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 İstanbul, 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 subtropical, 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*. London: Commonwealth Mycological.
- Gravesen, S. (1981). On the connection between the occurrence of airborne microfungi and allergy symptoms. *Grana*, 20, 225–227.
- Güner, A., Özhatay, N., Ekim, T., & Başer, K. H. C. (Eds.) (2000). *Flora of Turkey and the East Aegean Islands*, Vol. 11. Edinburgh: Edinburgh University Press.
- Harmanci, E., Metintas, M., & Erginel, S. (2000). Respiratory allergy to moulds among adults in Eskisehir Anatolia, Turkey. *Allergy et Immunology (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 Science & 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.
- Ocak, A., & Türe, C. (2001). The flora of the Meşelik campus of the Osmangazi University (Eskişehir – Turkey). *Ot Sistematik Botanik Dergisi*, 8, 19–46.
- Özdamar, K. (2004). *Paket Programlar ile İstatistiksel Veri Analizi 5. Baski*. Eskişehir, Türkiye: Kaan Kitapevi (pp. 535).
- 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 Pharmacy Gazi*, 11, 143–150.
- Pehlivan, S., & Ozler, H. (1999). The investigation of *Alternaria* spp. spores in the atmosphere of Sivas city. In *Proceedings of the 1st International Symposium on Protection of Natural Environment and Ehrami Karaçam 23–25th September, Kütahya, Türkiye*.
- Pepelnjak, S., & Seugic, M. (2003). Occurrence of fungi in air 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 and Built Environment*, 11, 285–292.
- Sen, B., & Asan, A. (2001). Airborne fungi in vegetable growing areas of Edirne, Turkey. *Aerobiologia*, 17, 69–75.
- 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 inhalant allergens. 1. Pollens and fungi. In E. Middleton, C. E. Reed, & E. F. Ellis (Eds.) *Allergy: Principles and practice* (pp. 312–372). St. Louis: Mosby.
- Tilak, S. T. (1991). Fungal Spores and Allergy. *Journal of Palynology*, 27, 369–386.
- Türe, C. (2002). *Sivrihisar dağlarının (Eskişehir) Floristik ve Ekolojik Yönden İncelenmesi*. Anadolu Üniversitesi Araştırma Fonu Projesi, AÜAF 001060.
- Wynn-Williams, D. D. (1991). Aerobiology and colonization in Antarctica: The BIOTAS Programme. *Grana*, 30, 380–393.