

***Alternaria* and *Cladosporium* spores in the atmosphere of Konya and their relationship with meteorological factors**

Konya ili atmosferinde bulunan *Alternaria* ve *Cladosporium* sporları ve meteorolojik faktörlerle ilişkisi

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ABSTRACT

Objective: The aim of this study was to determine the meteorological factors (temperature, relative humidity, wind speed, wind direction, rainfall) affecting *Alternaria* and *Cladosporium* spores in the atmosphere of Konya, Turkey.

Materials and Methods: Measurement of *Alternaria* and *Cladosporium* spores were carried out between January 1st 2008 and December 31st 2009, with a Burkard Volumetric 7-Days Spore Trap. Microscope counts were converted into atmospheric concentrations and expressed as spore/m³.

Results: While *Alternaria* spores were identified as 424 (19.2%) and 3977 (8.6%) spores/m³; *Cladosporium* spores were detected as 1784 (80.8%) and 42158 (91.4%) spores/m³ in 2008 and 2009 years, respectively. The daily concentrations of *Cladosporium* spore in 2008 were positively correlated with daily mean temperature (r= 0.181, p= 0.045), maximum temperature (r= 0.193, p= 0.033) and wind speed (r= 0.242, p= 0.007) and whereas they were negatively correlated with relative humidity (r = -0.215, p = 0.017). The daily concentrations of *Alternaria* and *Cladosporium* spore in 2009

ÖZ

Giriş: Bu çalışmanın amacı; Konya ili atmosferindeki *Alternaria* ve *Cladosporium* sporlarını etkileyen meteorolojik faktörleri (sıcaklık, nispi nem, rüzgar hızı, rüzgar yönü ve yağış miktarı) saptamaktır.

Gereç ve Yöntem: *Alternaria* ve *Cladosporium* sporları 1 Ocak 2008-31 Aralık 2009 tarihleri arasında Burkard cihazıyla toplandı. Mikroskopik sayımlar atmosferik konsantrasyonlara çevrildi ve spor/m³ şeklinde ifade edildi.

Bulgular: 2008-2009 yıllarında sırasıyla, 424 (%19.2) ve 3977 (%8.6) spor/m³ *Alternaria* sporu, 1784 (%80.8) ve 42.158 (%91.4) spor/m³ *Cladosporium* sporu tespit edildi. 2008 yılında *Cladosporium* konsantrasyonu ile günlük ortalama sıcaklık (r= 0.181, p= 0.045), maksimum sıcaklık (r= 0.193, p= 0.033) ve rüzgar hızı (r= 0.242, p= 0.007) arasında pozitif korelasyon; nispi nem (r= -0.215, p= 0.017) ile negatif korelasyon saptandı. 2009 yılında ise *Alternaria* ve *Cladosporium* spor konsantrasyonlarının, günlük ortalama sıcaklık (r= 0.44, p< 0.001; r= 0.44, p< 0.001), minimum sıcaklık (r= 0.46, p< 0.001; r= 0.44, p< 0.001) ve maksimum sıcaklık (r= 0.40, p< 0.001; r=

were found to be positively correlated with the daily mean temperature ($r=0.44$, $p<0.001$; $r=0.44$, $p<0.001$), the minimum temperature ($r=0.46$, $p<0.001$; $r=0.44$, $p<0.001$) and the maximum temperature ($r=0.40$, $p<0.001$; $r=0.43$, $p<0.001$) whereas they were negatively correlated with the relative humidity ($r=-0.29$, $p<0.001$; $r=-0.37$, $p<0.001$), respectively.

Conclusion: These findings showed that the concentrations of *Alternaria* and *Cladosporium* spores in Konya were affected from meteorological factors. *Cladosporium* spores were detected higher than *Alternaria* spores.

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Key words: *Alternaria*, *Cladosporium*, meteorological factors, Konya

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INTRODUCTION

The diversity, amount and the distribution of the fungal spores in the atmosphere are affected by the geographical coordinates, the vegetation and several meteorological factors including the temperature, day length, the wind velocity, the relative humidity and the precipitation. Along with being identified as significant disease-causing agents in plants and animals, fungal spores also give rise to allergic reactions in human. Specifically, spores of *Alternaria* and *Cladosporium* genera of the Deuteromycotina group are among the most important fungal spores causing allergic reactions^[1,2]. Exposure to *Cladosporium* spores in high concentrations affects the human health by increasing the incidence of asthma^[3]. Epidemiological studies from a variety of locations worldwide, indicate that *Alternaria* sensitivity is closely linked with the development of asthma. In addition, up to 70% of mold-allergic patients have skin test reactivity to *Alternaria*, and *Alternaria* sensitivity has been shown to be a risk factor for asthma^[4]. More people are allergic to *Alternaria* than *Cladosporium*. *Alternaria* also produces stronger positive reactions, while *Cladosporium* generally only produces a mild allergic reaction^[5,6].

0.43, $p<0.001$) ile pozitif ilişkili olduğu; nispi nem ile ($r=-0.29$, $p<0.001$; $r=-0.37$, $p<0.001$) negatif korelasyonu olduğu bulundu.

Sonuç: Konya ili atmosferindeki *Alternaria* ve *Cladosporium* miktarı meteorolojik faktörlere göre değişiklik göstermektedir. Ayrıca, *Cladosporium*'a ait sporlar *Alternaria* sporlarından daha yoğun olarak tespit edilmiştir.

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Anahtar kelimeler: *Alternaria*, *Cladosporium*, meteorolojik faktörler, Konya

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Alternaria genus consists of more than 100 species, usually found in plants, paper, leather, and upholstery as well as the food stuffs^[7,8]. *Cladosporium* genus consists of more than 30 species, present in plants, wood products and leather goods^[6,8]. Additionally, some researchers have indicated that the spores of these genera are more abundant in warmer climates^[9,10].

The concentrations of spore belonging to these genera has been investigated in various parts of the world and their relation to the meteorological factors has been reported^[8,11-13]. In Turkey, studies on the presence of fungal spores were performed in some cities and different methods were defined in the determination of fungal spores in Turkey^[13-22]. In this study, we aimed to determine the concentrations of *Alternaria* and *Cladosporium* spore and to identify the relationship between spore numbers and meteorological factors in the atmosphere of the Konya district.

MATERIALS and METHODS

The Area of Study

Konya is a city located between the 36°41' and 39°16' northern altitudes and the 31°41' and 34°26' eastern longitudes (Figure 1). The average

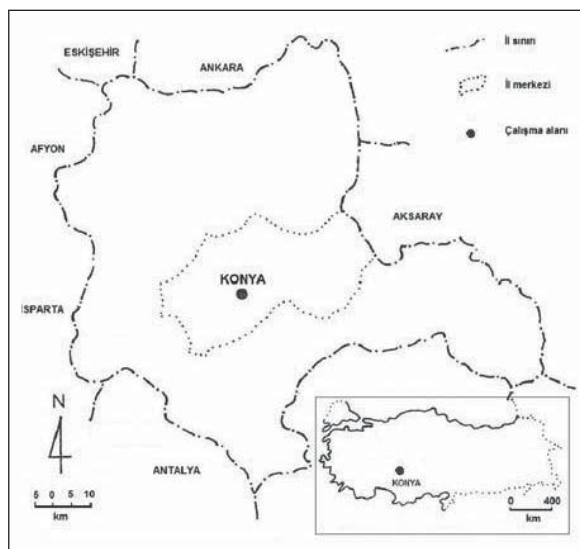


Figure 1. A location map of Konya.

altitude is 1016 m and the altitude of the city center is 1028 m. According to Kaya and Aladag, this area belongs to the Irano-Turanian phytogeographical region^[23]. The total amount of woodland located within the city borders of Konya is about 549.000 hectares.

Air Sampling

Alternaria and *Cladosporium* spore measurements were carried out in Konya, during two years from January 2008 to December in 2009, with a Burkard Volumetric 7-Days Spore Trap. The trap was placed on the terrace of children's hospital in the Selcuk University, Meram Faculty of Medicine, at a height of 7 meters above the ground level.

A Burkard spore trap was fitted for a seven day sampling onto Melinex tape which was coated with a thin film of Lubriseal (Thomas Scientific, Swedesboro, NJ). Tapes were changed weekly, cut into 48 mm segments, and mounted on microscope slides. The slides were colored with glycerin jelly containing basic fuchsin and were examined microscopically at 400x using a single longitudinal traverse. Microscope counts were converted into atmospheric concentrations and expressed as spore/m³.

Meteorological Data

Konya has a typical continental climate. According to the data in 2008-2009 obtained from the Turkish State Meteorological Service, the mean temperature was 13.1 ± 2.88 and $13.05 \pm 2.29^\circ\text{C}$ in 2008, and 2009, respectively. The minimum temperature was 7.88 ± 0.46 and $8.26 \pm 0.36^\circ\text{C}$ in 2008, and 2009, respectively. The maximum temperature was 19.59 ± 0.59 and $19.08 \pm 0.48^\circ\text{C}$ in 2008, and 2009, respectively (Figure 2). The relative humidity was $55.21 \pm 5.12\%$ and $58.48 \pm 4.59\%$, the wind speed was 1.27 ± 0.09 m/sec and 1.18 ± 0.12 m/sec and the rainfall was 24.49 ± 5.10 mm and 34.18 ± 7.24 mm in 2008 and 2009, respectively (Figures 3,4). In addition, while the amount of rainy days was 66 days in 2008, there were total 105 rainy days in 2009 (Figure 5).

Statistical Methods

Statistical analyses were performed using SPSS 15 for Windows (Chicago, IL, USA). Normality of the daily total concentrations of *Alternaria* and *Cladosporium* spore and daily meteorological parameters was assessed by the Kolmogorov-Smirnov test. The relationships between the daily total concentrations of *Alternaria* and

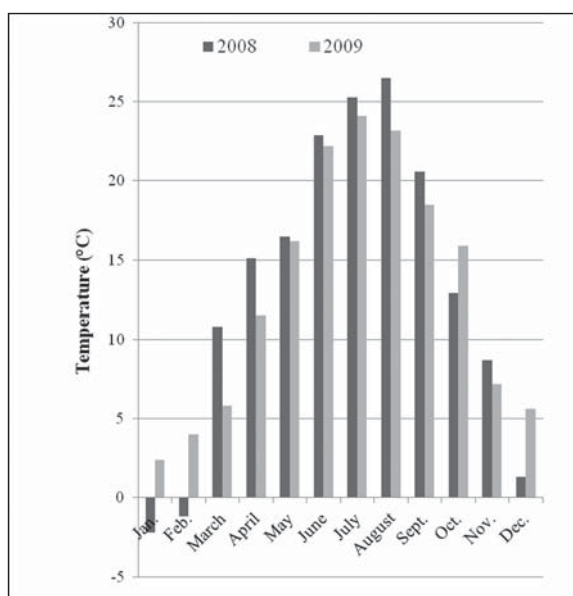


Figure 2. Monthly temperature changes in Konya in January 2008 and December 2009.

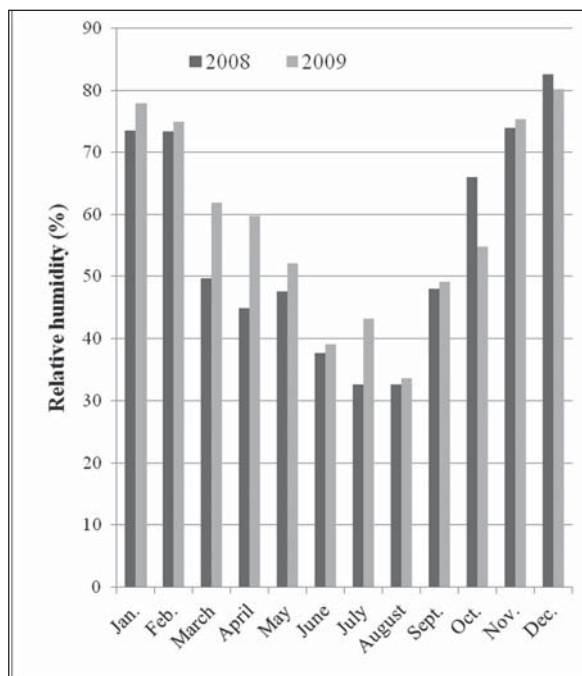


Figure 3. Monthly relative humidity changes in Konya in January 2008 and December 2009.

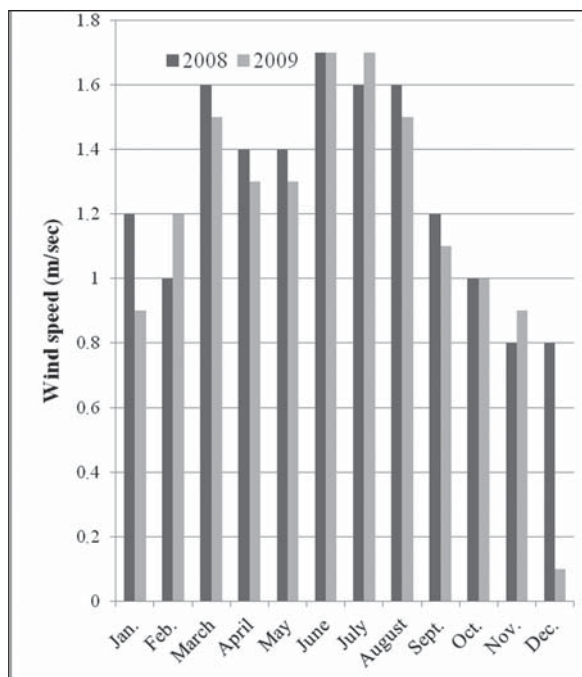


Figure 4. Monthly wind speed changes in Konya in January 2008 and December 2009.

Cladosporium spore in the atmosphere of the city of Konya in 2008-2009 were investigated in relation to the daily mean temperature,

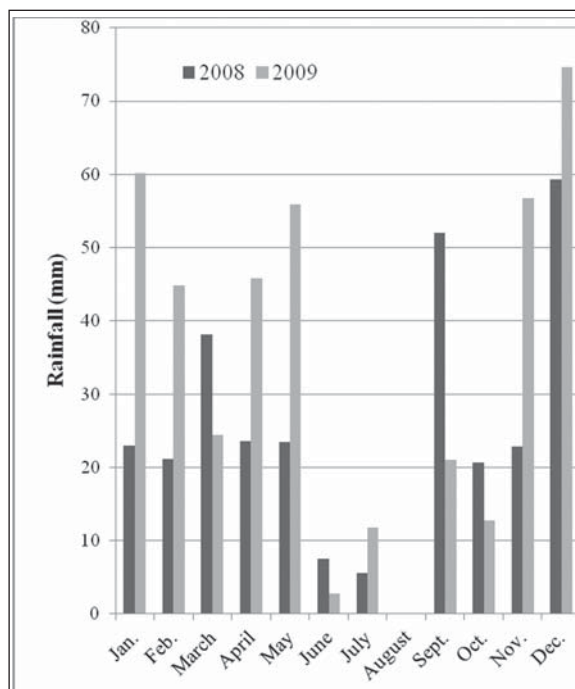


Figure 5. Monthly rainfall changes in Konya in January 2008 and December 2009.

minimum temperature, maximum temperature, relative humidity, wind speed and total rainfall values using the Spearman correlation analysis. The comparison of meteorological parameters between 2008 and 2009 was made by a non-parametric Mann-Whitney U test. The $p < 0.05$ value was accepted as statistically significant.

RESULTS

In the samples taken from the atmosphere of Konya between January 1st 2008 and December 31st 2009, 48.343 spore/m³ were classified for *Alternaria* and *Cladosporium* genus spores. The samples from the year 2008 contained 424 (19.2%) spores/m³ belonging to *Alternaria* and 1784 (80.8%) spores/m³ belonging to *Cladosporium*; whereas in 2009, *Alternaria* and *Cladosporium* were identified as 3977 (8.6%) and 42.158 (91.4%) spores/m³, respectively (Figures 6,7).

The spores reached a maximum with their concentrations in the last week of May in 2008 and the first week of July in 2009. *Alternaria* and *Cladosporium* spores were frequently encountered in 2008 starting on 05.20.2008 and on 05.26.2008 (relative humidity: 51; mean tempera-

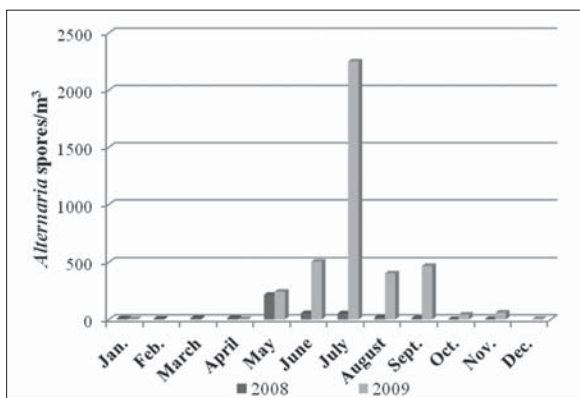


Figure 6. Daily concentrations of the *Alternaria* spores in the atmosphere of Konya in 2008 and 2009.

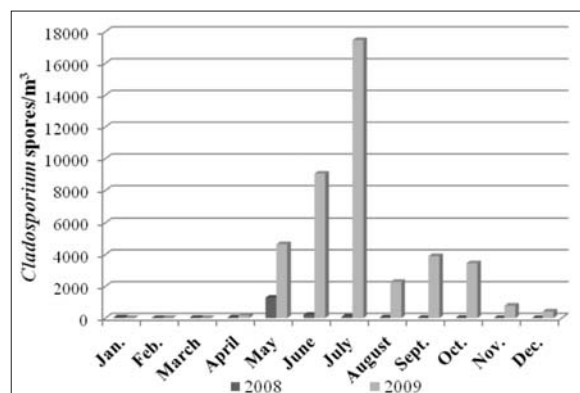


Figure 7. Daily concentrations of the *Cladosporium* spores in the atmosphere of Konya in 2008 and 2009.

ture: 18°C; wind direction: north northeast), on which days they reached a maximum concentration of 77 spore/m³ and 406 spore/m³, respectively. *Alternaria* spores were less dense and were encountered less frequently in the Konya atmosphere from 07.18.2008 onwards, whereas for *Cladosporium* spores, from 08.08.2008 onwards. In 2009, *Alternaria* and *Cladosporium* spores were first detected on 05.01.2009. On 07.06.2009 (relative humidity: 46.4; mean temperature: 22°C; wind direction: west), *Alternaria* spores reached a maximum concentrations of 243 spore/m³ and on 07.05.2009 (relative humidity: 58; mean temperature: 22°C; wind direction: north northeastern), while *Cladosporium* spores reached a maximum concentration of 3803 spore/m³. The concentrations of the spores from both genera began to decrease from 08.21.2009 onwards. However,

the spores of these fungi were frequently detected again in 2009 between the dates 09.08.2009 and 09.17.2009. During this period, *Alternaria* spores were at their peak value on 09.15.2009 (relative humidity: 33.7; mean temperature: 19°C; wind direction: west) and *Cladosporium* spores were at their peak value on 09.14.2009 (relative humidity: 34.5; mean temperature: 18.2°C; wind direction: south southwest).

The meteorological parameters for the years 2008 and 2009 were evaluated together with the distribution of the concentrations of *Alternaria* and *Cladosporium* spore. The daily concentrations of the *Alternaria* spore present in the Konya atmosphere in 2008 were positively correlated with the mean daily temperature ($r = 0.53$), minimum temperature ($r = 0.066$), maximum temperature ($r = 0.067$) and wind speed ($r = 0.032$) and they were negatively correlated with relative humidity ($r = -0.111$) and the amount of rainfall ($r = -0.22$), although these correlations were not statistically significant ($p > 0.05$) (Table 1). During this period, a statistically significant relationship between the concentrations *Cladosporium* spore and the meteorological parameters was detected; daily concentrations were positively correlated with daily mean temperature ($r = 0.181$) and maximum temperature ($r = 0.193$) whereas they were negatively correlated with relative humidity ($r = -0.215$) ($p < 0.05$) (Table 1). In 2009, the daily concentrations of *Alternaria* and *Cladosporium* spore were found to be positively correlated with the daily mean temperature ($r = 0.44$, $r = 0.44$), the minimum temperature ($r = 0.46$, $r = 0.44$) and the maximum temperature ($r = 0.40$, $r = 0.43$) whereas they were negatively correlated with the relative humidity ($r = -0.29$, $r = -0.37$) in a statistically significant ($p < 0.001$) (Table 1). A negative correlation between the daily concentrations of *Alternaria* and *Cladosporium* spore and the amount of rainfall ($r = -0.055$, $r = -0.130$) was identified, although this relationship was not found to be statistically significant ($p > 0.05$) (Table 1). The northerly and northeasterly winds were dominant in 2008 and northeasterly winds were dominant in 2009 (Table 2). Easterly and

Table 1. The relationship between the daily amount of the *Alternaria* and the *Cladosporium* spores detected in the atmosphere of the city of Konya and the meteorological variants in 2008 and 2009

| | 2008 | | | | 2009 | | | |
|--------------------------|-------------------|-------|---------------------|-------|-------------------|---------|---------------------|---------|
| | <i>Alternaria</i> | | <i>Cladosporium</i> | | <i>Alternaria</i> | | <i>Cladosporium</i> | |
| | r | p | r | r | r | p | r | p |
| Mean temperature (°C) | 0.53 | 0.655 | 0.181* | 0.045 | 0.44** | < 0.001 | 0.44** | < 0.001 |
| Minimum temperature (°C) | 0.066 | 0.577 | 0.175 | 0.054 | 0.46** | < 0.001 | 0.44** | < 0.001 |
| Maximum temperature (°C) | 0.067 | 0.569 | 0.193* | 0.033 | 0.40** | < 0.001 | 0.43** | < 0.001 |
| Relative humidity (%) | -0.111 | 0.345 | -0.215* | 0.017 | -0.29** | < 0.001 | -0.37** | < 0.001 |
| Wind speed (m/sec) | 0.032 | 0.788 | 0.242** | 0.007 | 0.66 | 0.424 | 0.24 | 0.716 |
| Rainfall (mm) | -0.22 | 0.301 | -0.117 | 0.201 | -0.055 | 0.506 | -0.130 | 0.053 |

* Correlation is significant at the 0.05 level (2-tailed),

** Correlation is significant at the 0.01 level (2-tailed).

Table 2. Wind direction and their frequencies in the atmosphere of Konya

| Wind direction | 2008 | 2009 |
|-----------------|-----------|-----------|
| | Frequency | Frequency |
| South southwest | 12 | 20 |
| Northwest | 15 | 21 |
| East northeast | 26 | 19 |
| South southeast | 14 | 20 |
| East | 33 | 20 |
| North | 35 | 22 |
| North northeast | 57 | 41 |
| North northwest | 12 | 9 |
| West northwest | 25 | 24 |
| East southeast | 17 | 20 |
| Northeast | 55 | 46 |
| Southeast | 13 | 17 |
| Southwest | 4 | 13 |
| West | 32 | 29 |
| South | 16 | 24 |
| West southwest | 0 | 20 |

southeasterly winds were not observed in the Konya atmosphere in 2008 (Table 2).

Significant differences were observed for the daily relative humidity, the wind speed, the wind direction and the amount of rainfall values between the years 2008 and 2009 ($p < 0.05$) (Table 3). The differences in the daily mean

temperature, the minimum temperature and the maximum temperature values between the years 2008 and 2009 are noteworthy although statistically insignificant.

DISCUSSION

In this study, conducted in 2008-2009 in Konya, *Cladosporium* spores were found to be more abundant than *Alternaria* spores (Figures 6,7), consistent with the aeropalynological reports of many other researchers^[6,8,12,14,16-18,24-28]. The growth, the sporulation and the dispersion of both *Alternaria* and *Cladosporium* genera are affected from the meteorological changes^[10,12,29]. Several researchers have reported the necessity for high temperatures (15-29°C), high relative humidity (50-80%) and rainfall for the formation of *Alternaria* and *Cladosporium* spores^[10,30,31]. In our study, the concentrations of spore varied with respect to the meteorological changes as well. The period when the mean temperature varied between 15-29°C and the relative humidity varied between 50-80% was only for a duration of 16 days in our region of study in 2008. In addition, only 13 days were rainy in this period; the amount of rainfall varied between 0.1 and 15.7 mm. The period when the mean temperature varied between 15-29°C and the relative humidity varied between 50-80% was for a duration of 54 days in our region of study in 2009.

Table 3. The comparison of meteorological parameters in the atmosphere of Konya between 2008 and 2009

| | Mean temperature (°C) | Minimum temperature (°C) | Maximum temperature (°C) | Relative humidity (%) | Wind speed (m/sec) | Wind direction | Rainfall (mm) |
|----------------|-----------------------|--------------------------|--------------------------|-----------------------|--------------------|----------------|---------------|
| Mann-Whitney U | 64901.500 | 66581.000 | 63460.500 | 59142.500 | 50948.500 | 60462.500 | 57610.500 |
| p | 0.548 | 0.991 | 0.269 | 0.009 | < 0.001 | 0.026 | 0.001 |

During this period, the amount of rainy days was 30 and the amount of rainfall varied between 0.1 and 22.8 mm. It is therefore determined that more suitable conditions for the formation of *Alternaria* and *Cladosporium* spores were present in 2009 than in 2008.

In 2008, a statistically significant positive correlation was determined between the concentrations of *Cladosporium* spore and the mean daily and the maximum temperature values whereas in 2009, a statistically significant positive correlation was determined between the concentrations of both *Alternaria* and *Cladosporium* spore and the mean daily, the maximum temperature and the minimum temperature values (Table 1).

It has been reported in previous research studies that temperature plays an important role on the concentrations of airborne *Alternaria* and *Cladosporium* spore^[12-15,17,24,32-35]. In only 2008, a significant positive correlation was found between wind speed and *Cladosporium* spores (Table 1). Rodriguez-Rajo et al. found a positive interaction between *Cladosporium* concentration and wind speed in a study conducted in 2002^[10]. Some researchers have noted that the speed of wind positively affects the dispersion of the genus in question^[13,30]. In our region of study, the north-northeasterly and westerly winds were dominant when the concentrations of *Alternaria* spore peaked and north-northeasterly, westerly or south-south westerly winds were dominant when the concentrations of *Cladosporium* spore peaked. A negative but statistically insignificant relationship was determined between *Alternaria*

spores and the relative humidity in 2008. On the other hand, the negative relationship between the relative humidity and *Cladosporium* spores in 2008 and the negative relationship between the relative humidity and both *Alternaria* spores and *Cladosporium* spores in 2009 were found to be statistically significant.

Many other researchers have reported similar results in the past regarding the relative humidity^[12,14,33,35]. A negative but insignificant correlation was detected between daily rainfall and *Alternaria* and *Cladosporium* spore in 2008 and 2009. The negative effect of precipitation on the extent of spore dispersion in the atmosphere has been discussed by many other researchers^[12-14,17,35]. Some researchers have considered the reason for this phenomenon to be the washing down of the spores from the atmosphere by precipitation^[36,37].

Ceter and Pinar detected to fungal spores in all months in Ankara (Turkey) atmosphere between January to December 2003^[14]. The evaluation of the seasonal distribution of spore concentrations revealed that the highest value was detected in July (100.697 spores/m³), while the lowest value was in January (4268 spores/m³). When the effects of meteorological factors on spore concentrations were investigated, it was found that, monthly mean temperature (> 20°C) has a strong positive correlation, and monthly mean relative humidity (< %50) and precipitation (0-20 mm) have strong negative correlations on the spore concentrations, while wind velocity (3 m/s) has a slightly positive effect. Şakıyan and Inceoğlu also identified that *Cladosporium* and

Alternaria spores were highly abundant in the Ankara atmosphere; of *Cladosporium* a total of 511.232 spores/m³ was counted and of *Alternaria* 59.735 spores/m³ in 1990^[18]. *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*. The highest concentrations of airborne *Cladosporium* and *Alternaria* spores were recorded during summer. Both spore types are present in lower levels in winter. The peak period starts during the second half of June and lasts until the middle of August for *Cladosporium*. *Alternaria* spore concentrations were maximal in spring (April-May) and summer (July-August). In our study, peak concentration of fungi was detected in May, 2008 and in July, 2009 in the atmosphere of Konya.

Potoglu Erkara et al. identified a total of 10231 spores from *Cladosporium* and *Alternaria*, 5103 in 2000 and 5128 in 2001 in the atmosphere of Eskisehir (Turkey)^[13]. The peak period started during the second half of April and lasted until the second week of June for *Cladosporium*. The highest weekly concentration was recorded in the second week of May. *Alternaria* spore concentrations were maximal in Spring (April-May) and Summer (July-August). The initial seasonal peak occurred during the second week of April and lasted until the second week of June for *Alternaria*. Maximum counts were recorded during the second week of May. In our study region, though, the concentrations of spore of these genera peaked in May 2008 and in July and in September 2009 (Figures 6,7).

Kilic et al. found a positive correlation between atmospheric concentration of *Alternaria* spores and temperature, while detected a negative correlation with barometric pressure in the atmosphere of Adana (Turkey)^[15]. However they could not find any correlation between concentration of *Alternaria* spores and meteorological parameters such as humidity,

rainfall, mean and maximum wind speed. Inal et al. found highest outdoor fungi concentration in June, followed by August and July, and the lowest in January in the atmosphere of Adana^[17]. *Cladosporium* was the predominant fungi in atmosphere throughout the year; but, surprisingly only in August *Alternaria* counts exceeded *Cladosporium*. they also found significant correlation between the concentration of outdoor fungi and meteorological conditions such as average monthly temperature, relative humidity, precipitation and velocity of the wind of the month, and number of rainy days of the month.

Celenk et al. detected a total 6318 spores/cm² belonging to *Alternaria* and *Cladosporium* during the 2000-2001 in the atmosphere of Edirne (Turkey)^[19]. Out of the total, 5095 spores/cm² belonged to *Cladosporium* spp. and remaining 1223 spores/cm² to *Alternaria*. In the atmosphere of Edirne, *Alternaria* and *Cladosporium* spp. were found every month of the year. Maximum spores were encountered in July.

Boyacıoğlu et al. have studied the differences, if any, in the concentrations of several fungal spore around Buca, Konak, Bornova, and Karsiyaka provinces in Izmir and attempted to identify the reasons behind these differences if they existed^[20]. Fungus (cfu/m³) in the air samples collected from each station between June 2003 and May 2004 measured. The results revealed that whereas Karsiyaka had the highest fungus concentrations (521.33 ± 777.1), Buca and Bornova had the lowest concentrations (482.67 ± 308.44). The mean fungus concentration in the province of Izmir was 501.5 ± 486.7. With this study, they have identified that the concentrations of the fungal spore (cfu/m²) did not reach concentrations that would impose an allergic risk in humans according to the standards of the American Academy of Allergy, Asthma and Immunology Records at any time period.

According to the classification of American Academy of Allergy, Asthma and Immunology, the lower limit for the fungal spore to cause allergic reactions in sensitive individuals is 6500^[38].

In Konya, the level of fungal spore reached that number only in June and July 2009. A very restricted number of studies using gravimetric or volumetric methods have been conducted in Turkey and in most of them the monthly spore concentrations are less than 6000 per m³[13,19-21]. However, according to Gravesen, in order for the spores of *Alternaria* and *Cladosporium* to trigger allergic reactions, it is sufficient to have them in the atmosphere at concentrations of 100 spore/m³ and 3000 spore/m³, respectively[39]. Under this limitation, in order for *Alternaria* spores to cause allergic reactions in the city of Konya, the concentration during the periods covering only May 2008 and May-September 2009 presented a risk (Figures 6,7). In terms of the likelihood of *Cladosporium* spores to cause allergic reactions, no risky period was detected in 2008 but concentrations during May-July 2009 did present a risky period. However, based on the daily concentrations of *Alternaria* and *Cladosporium* spores in the atmosphere, no days in 2008 and 2009 presented an allergic risk according to the standards of the American Academy of Allergy, Asthma and Immunology. On the other hand, although no day in 2008 imposed an allergic risk in terms of *Alternaria* and *Cladosporium* spores according to the standards imposed by Gravesen, 12 days were risky in terms of *Alternaria* spores and 1 day was risky in terms of *Cladosporium* spores in 2009 (Figures 6,7)[39].

We attempted to explain the differences in the concentrations of *Alternaria* and *Cladosporium* spores between 2008 and 2009 in terms of the meteorological factors (temperature, relative humidity, wind speed and direction, amount of rainfall). The position of the Burkard equipment was not changed in the years 2008-2009 and the air-suction capacity of the equipment was measured weekly using a flow meter; an undesirable situation was not detected. In addition, the spore counts were carried out by the same person all the time. We think that the differences in the concentrations in the spore counts were the result of the changes in the meteorological factors in the region, especially in the amount

of rainfall. Differences in vegetation might have also occurred during this period.

In this study, the concentrations and the period of dispersion of *Alternaria* and *Cladosporium* spore that can cause sickness in animals and plants and that can result in allergic symptoms in human beings have been determined. We believe that the determination of the spore concentration in the atmosphere will be helpful to microbiologists, mycologists and phyto-pathologists as well as the allergy doctors.

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