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Pollen grains in the atmosphere of Konya (Turkey) and their relationship with meteorological factors, in 2008

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Abstract: Atmospheric pollen was collected by a Burkard Volumetric 7-Day spore trap in Konya, Turkey, in 2008. In the present study, the pollen concentration is presented in relation to meteorological parameters (mean temperature, relative humidity, rainfall, and wind speed). Pollen grains of 35 taxa were identified. Of these, 18 taxa were arboreal plants, while the others were non-arboreal plants. The distribution of the total pollen grains was as follows: arboreal plants, 61.29%; Poaceae, 16.09%; non-arboreal plants, 20.25%; and undetermined, 2.37%. Arboreal taxa pollen were represented by Pinaceae, Cupressaceae/Taxaceae, Fabaceae, Betulaceae, *Quercus* L., Juglandaceae, and *Aesculus* L., while non-arboreal taxa pollen were represented by Poaceae, Asteraceae, Chenopodiaceae/Amaranthaceae, Brassicaceae, Boraginaceae, *Plantago* L., and Urticaceae. These were the dominant pollen types found in the atmosphere in Konya. In addition, there are generally significant positive effects of temperature and wind speed and a negative influence of relative humidity on the daily pollen levels belonging to those taxa which contribute more than 1% of the total pollen in the Konya atmosphere. The findings of the present study may be helpful for designing allergen panels as well as for allergy doctors and patients suffering from pollen allergies.

Key words: Aerobiology, arboreal plants, non-arboreal plants, Poaceae, meteorological parameters

2008 yılında Konya (Türkiye) atmosferinde bulunan polenler ve bunların meteorolojik faktörler ile arasındaki ilişki

Özet: Konya (Türkiye) atmosferindeki polenler, Burkard spor ve polen tutma aleti ile toplanmıştır. Polen yoğunluklarının meteorolojik parametreler (ortalama sıcaklık, bağıl nem, yağış miktarı, rüzgar hızı) ile arasındaki ilişki gösterilmiştir. Bir yıllık dönemde 35 taksona ait polenler tanımlanmıştır. 18 takson odunlu ve diğerleri otsu bitkilere ait taksonlardır. Toplam polenlerin dağılımı ise şu şekildedir: odunlu bitkiler %61,29, Poaceae % 16,09, otsu bitkiler % 20,25 ve % 2,37 tanımlanamayanlardır. Konya atmosferinde odunlu taksonlardan Pinaceae, Cupressaceae/Taxaceae, Fabaceae, Betulaceae, Quercus L., Juglandaceae ve *Aesculus* L. polenleri, otsu taksonlardan Poaceae, Asteraceae, Chenopodiaceae/Amaranthaceae, Brassicaceae, Boraginaceae, *Plantago* L. ve Urticaceae polenleri çoğunlukla gözlenmiştir. Ayrıca, genel olarak Konya atmosferinde polen miktarı toplam polen miktarının % 1'inden daha fazla olan taksonların günlük polen miktarları ile sıcaklık ve rüzgar hızı arasında önemli ve pozitif, bağıl nem ile negatif bir ilişki vardır. Bu bulguların, alerjen panellerinin düzenlenmesine, alerji ile ilgilenen doktorlara ve polen alerjisi olan hastalara faydalı olacağını düşünmekteyiz.

Anahtar sözcükler: Aerobiyoloji, odunlu bitkiler, otsu bitkiler, Poaceae, meteorolojik faktörler

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Introduction

There are various biological particles in the atmosphere, including pollen grains, fungus spores, segments of hyphae, algae, small seeds, insect larvae, segments of insects, and protozoa of 0.5-100 µm in diameter. Pollen grains are the most important particles activating the immune system and causing allergic rhinitis symptoms. Therefore, to facilitate the diagnosis and treatment of allergic diseases, studies are conducted both nationally and internationally to determine the taxa to which the pollen belongs, the amount of pollen, and changes in the atmosphere in accordance with meteorological factors (Doğan & Erik, 1995; Doğan & İnceoğlu, 1995; Leuschner et al., 2000; Stach, 2000; Henrìquez et al., 2001; Alcázar et al., 2003; Green et al., 2003; Vázquez et al., 2003; Altintaş et al., 2004; Damialis et al., 2005; Hasnain et al., 2005; Rodríguez-Rajo et al., 2005; Bianchi & Olabuenaga, 2006; Teranishi et al., 2006; Avolio et al., 2008; Garciá-Mozo et al., 2008; Waisel et al., 2008; Erkan et al., 2011).

Konya is the largest province in Turkey, with a population of about 2 million. In addition, Konya is an important place for tourism as it is the home of the renowned Mevlana's mausoleum and historical buildings such as the Karatay Madrasa and the Alaadin Keykubat Mosque. Konya is also an important agricultural area, where a lot of Poaceae species, such as *Triticum* L., *Secale* L., and *Hordeum* L., have been grown. The pollen of Poaceae is among the most allergenic pollen in Turkey and Europe. It has been observed that the people living in the city of Konya have high pollen allergy ailments. In an investigation performed in 2 schools in the Konya city centre, a questionnaire with questions used in the International Study of Asthma and Allergies in Children (ISAAC) was administered to a total of 986 students, 508 males and 478 females. The prevalence of asthma, allergic conjunctivitis, and atopic dermatitis were detected as 11.2%, 16.6%, and 1.9%, respectively, while the prevalence of doctor-diagnosed asthma-allergic bronchitis was 9.9% (Reisli et al., 2003). Therefore, the main aim of the present study was to reveal the taxa that exist in the Konya atmosphere. In addition, we aimed to examine the relationships between the daily pollen levels of 14 taxa that comprise more than 1% of the total pollen amount and meteorological parameters (mean temperature, relative humidity, wind speed, and rainfall) using the Spearman analysis.

Materials and methods

Location of the study area

Konya is located in the central plateau of Anatolia (39°57′N, 32°53′E) (Figure 1). The city has steppe vegetation. Within the borders of Konya, forest areas comprise 549,000 ha. These forest areas consist of species belonging to the genera *Pinus* L. (50%), *Juniperus* L. (25%), *Quercus* L. (8%), *Abies* Mill., and *Fraxinus* L. (2%). *Pyrus elaegrifolia* L. and *Ulmus* L. are found on the side of mountains and in the plains while *Crataegus* L. exist in patches in the steppe area. In addition, grassland areas make up 91,149 ha in the centre of Konya (RTMEF, 2004).

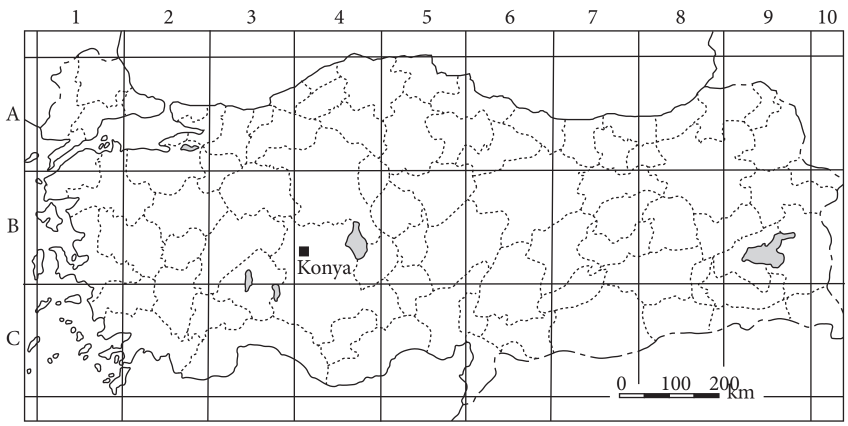

Figure 1.The location of Konya in Turkey.

Meteorological data

Konya has a typical continental climate. According to the data obtained from the Turkish State Meteorological Service, in 2008 the yearly mean temperature was 12.75 °C. The highest average temperature was 25.7 °C, in August; the lowest average temperature was –2.9 °C, in January. The mean annual rainfall during this period was 19.77 mm, relative humidity was 54.46%, and the yearly average for wind speed was 3.39 km/h. Monthly variations in meteorological parameters (temperature, rainfall, relative humidity, and wind speed) in the Konya atmosphere are presented in Figure 2.

Air sampling

Atmospheric pollens were collected with a Burkard Volumetric 7-Day spore trap from January to December 2008. The trap was placed 7 m above the ground on the terrace of the Children's Hospital of Meram Medical Faculty at Selçuk University.

A Burkard spore trap was set for 7 day sampling onto Melinex tape that was coated with a thin film of Lubriseal (stopcock grease, Thomas Scientific, Swedesboro, NJ, USA). Tapes were changed weekly before being cut into 48 mm segments and mounted on microscope slides. Slides were coloured with glycerine jelly containing basic fuchsin and examined at a magnification of ×400, using a single longitudinal traverse (Rogers & Muilenberg, 2001). Microscope counts were converted into atmospheric concentrations and expressed as pollen grains/m^3.

The identification of pollens was made using reference books (Wodehouse, 1935; Hyde, 1959; Aytuğ et al., 1971; Moore & Webb, 1983; Pehlivan, 1995; Erik & Doğan, 2002; Doğan Güner et al., 2011) and reference pollen slides featuring local flora.

Statistical methods

The relationships between the daily total pollen amounts from taxa that comprise more than 1% of the total pollen and meteorological parameters (mean temperature, relative humidity, wind speed, and rainfall) were examined using the Spearman analysis.

Results

In the study, a total of 4343 pollen grains belonging to 35 different taxa were determined in the atmosphere of Konya in 2008. Of these, 18 taxa were arboreal and the remaining 17 taxa were non-arboreal. Arboreal pollen displayed the highest proportion, at 61.29%, while Poaceae and other non-arboreal taxa had lower proportions of 16.09% and 20.25%, respectively. A further 103 pollen grains (2.37%) were not identified.

Monthly pollen counts and the number of taxa recorded showed variations during different months of the year. The highest pollen counts were recorded in May, while the lowest amount of pollen was counted in November and December. The highest number of taxa was recorded in May (24), whereas the lowest number of taxa was detected in February (6), November (6), and December (6) (Figure 3).

Pollen of the following taxa were also found to be common in the atmosphere of Konya: *Acer* L., *Aesculus* L., *Ailanthus* Desf., *Alnus* Miller, *Betula* L., Cupressaceae/Taxaceae, *Elaeagnus* L., Fabaceae, *Fraxinus* L., Juglandaceae, *Morus* L., Oleaceae, Pinaceae, *Populus* L., Rosaceae, *Quercus*, *Salix* L., *Tilia* L., Asteraceae, Apiaceae, Boraginaceae, Brassicaceae, Campanulaceae, *Carex* L., Caryophyllaceae, Chenopodiaceae/Amaranthaceae, Cistaceae, Ericaceae, Lamiaceae, Liliaceae, *Plantago* L., Poaceae, *Rumex* L., Urticaceae, and *Centaurea* L. (Table 1).

In addition, pollen seasons of the 14 most abundant taxa were characterised on the basis of weekly pollen levels. The results of this analysis are as follows.

The most abundant pollen type was Pinaceae, representing 29.36% of the total pollen and an annual total of 1275 pollen grains (Table 1). There was a significant increase in the concentration of Pinaceae in the atmosphere in the middle of April. During the period between the last week of May and the second week of June, the pollen of Pinaceae reached the highest peak. In November, December, and January, only a few Pinaceae pollen grains were observed (Figure 4).

Fabaceae pollen was also common in the annual pollen spectrum of the study area. This pollen formed 10.2% of the total pollen and the annual total for these pollen grains was 443 (Table 1). Pollen grains of Fabaceae were recorded frequently throughout the year, from February to November. Pollen grains of Fabaceae started to increase from April and reached

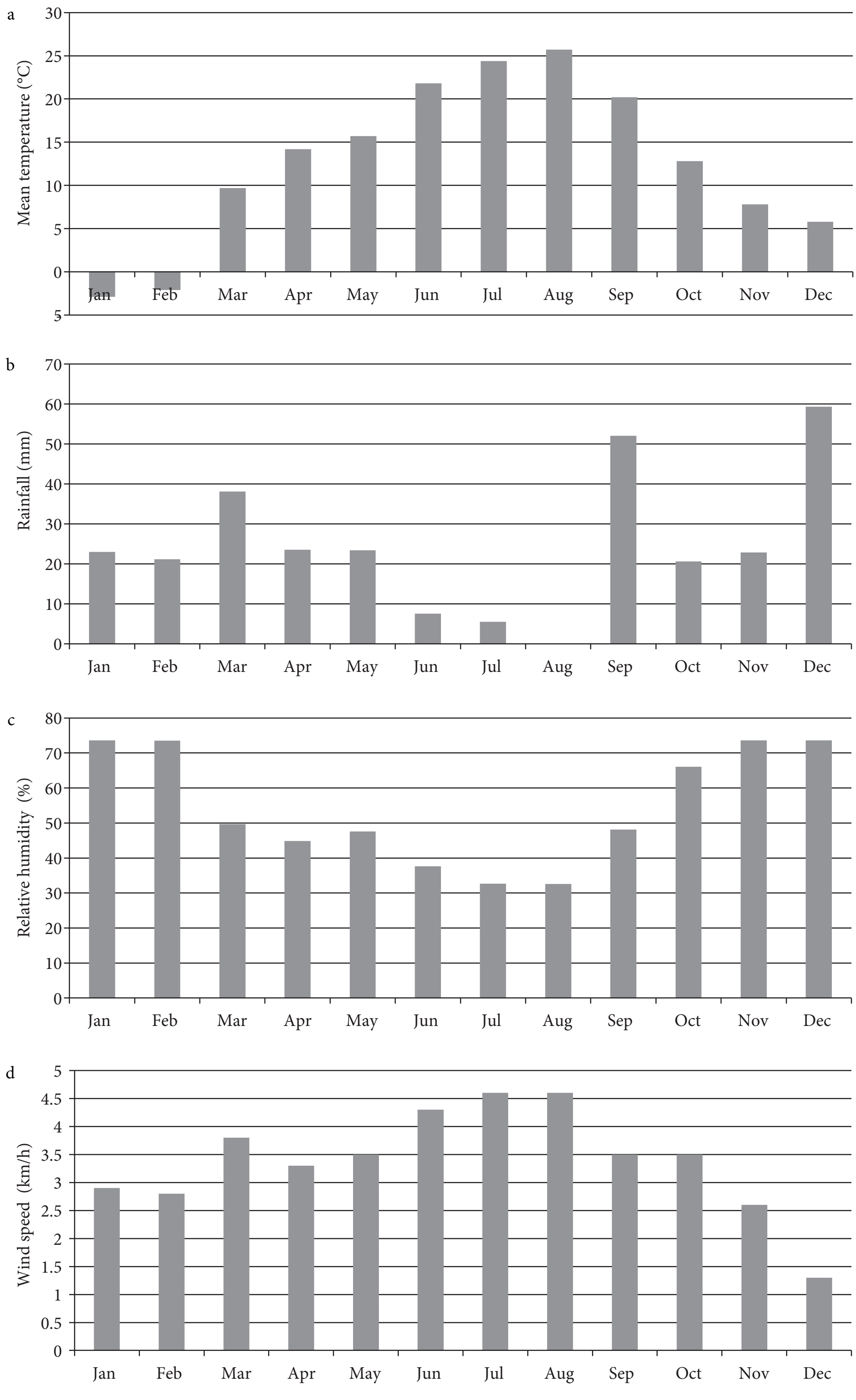

Figure 2. The monthly variation of meteorological parameters: mean temperature (a), rainfall (b), relative humidity (c), and wind speed (d) in the Konya atmosphere.

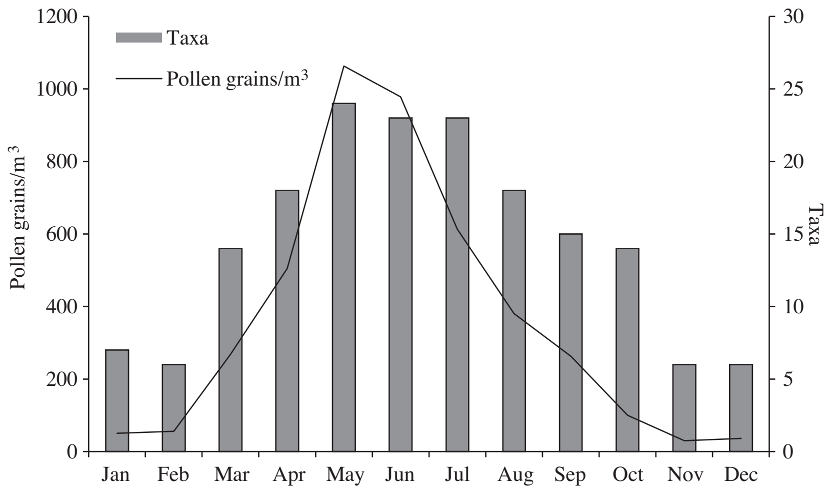

Figure 3. Monthly variations in pollen counts and taxa in the atmosphere of Konya in 2008.

the highest value in May and June. In November, only 2 Fabaceae pollen grains were identified (Figure 4).

Cupressaceae/Taxaceae was another abundant pollen type, making up 8.29% of the total pollen. The total annual amount of these pollen grains was 360 (Table 1). Pollen grains from these families were recorded all year round. The highest total value was noted in May (Figure 4).

Pollen grains of *Quercus* constituted 2.97% of the total counted pollen and its annual total number was 129 (Table 1). Pollen grains of the genus were observed constantly in the atmosphere, except for the months of January, February, November, and December. They reached the highest value in the first week of May (Figure 4).

Betulaceae pollen grains accounted for 2.72% of the total pollen with an annual total of 118 pollen grains (Table 1). Betulaceae pollens were encountered every month, with the exception of January, November, and December. The amount of this pollen reached a maximum value in the first week of April and then began to decrease. The pollen concentration of Betulaceae reached a minimum in October (Figure 5).

Juglandaceae pollen formed 2.23% of total pollen and the total number of pollen grains from this family was 97 (Table 1). Juglandaceae was recorded during a long pollen season, which started from the last week of March and ended in the fourth week of August, with a maximum concentration at the end of May (Figure 5).

Pollen grains of *Aesculus* formed 1.06% of the total pollen and the total annual number of these pollen grains was 46 (Table 1). These pollen types were observed in April, June, and October. The highest number of *Aesculus* pollen grains was found in April (Figure 5).

Pollen grains of Poaceae accounted for 16.09% of the total pollen, with an annual amount of 699 (Table 1). The pollen season began in January and finished at the beginning of October. The maximum concentration was determined from the last week of May to the first week of June. Pollen grains of Poaceae were not observed in November and December (Figure 6).

Chenopodiaceae/Amaranthaceae was among the most abundant taxa, accounting for 8.04% of the total pollen, with an annual total of 349 pollen grains (Table 1). Pollen grains of these taxa were detected in the atmosphere throughout the year, except for November. The highest counts were recorded from the last week of May to the first week of October (Figure 6).

Pollen grains of Boraginaceae accounted for 2.9% of the total pollen and their annual total was 126 (Table 1). Pollen production lasted from the last week

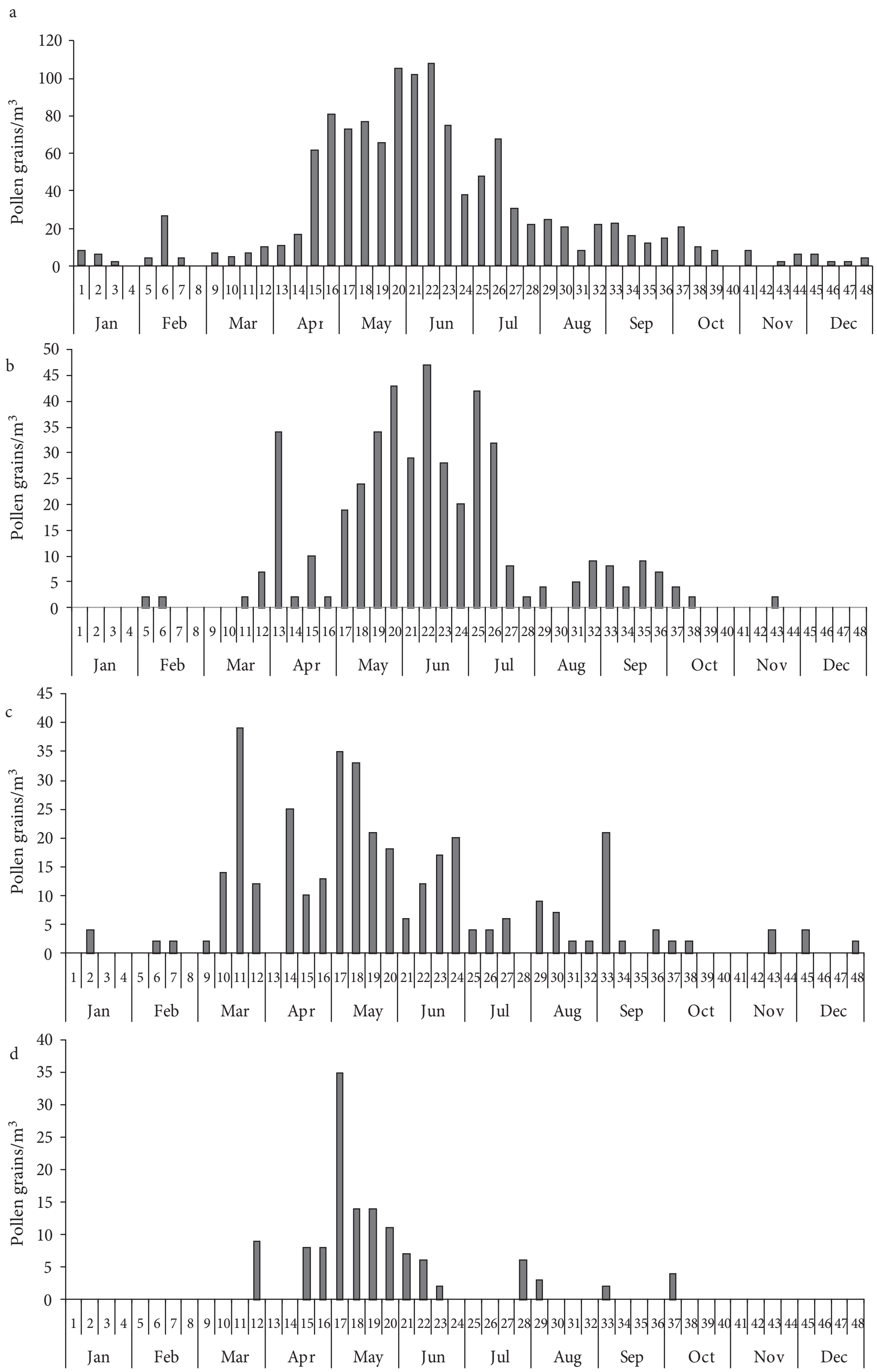

Figure 4. Weekly variations in the pollen counts of arboreal types representing more than 1% of the total pollen in the atmosphere of Konya: Pinaceae (a), Fabaceae (b), Cupressaceae/Taxaceae (c), *Quercus* (d).

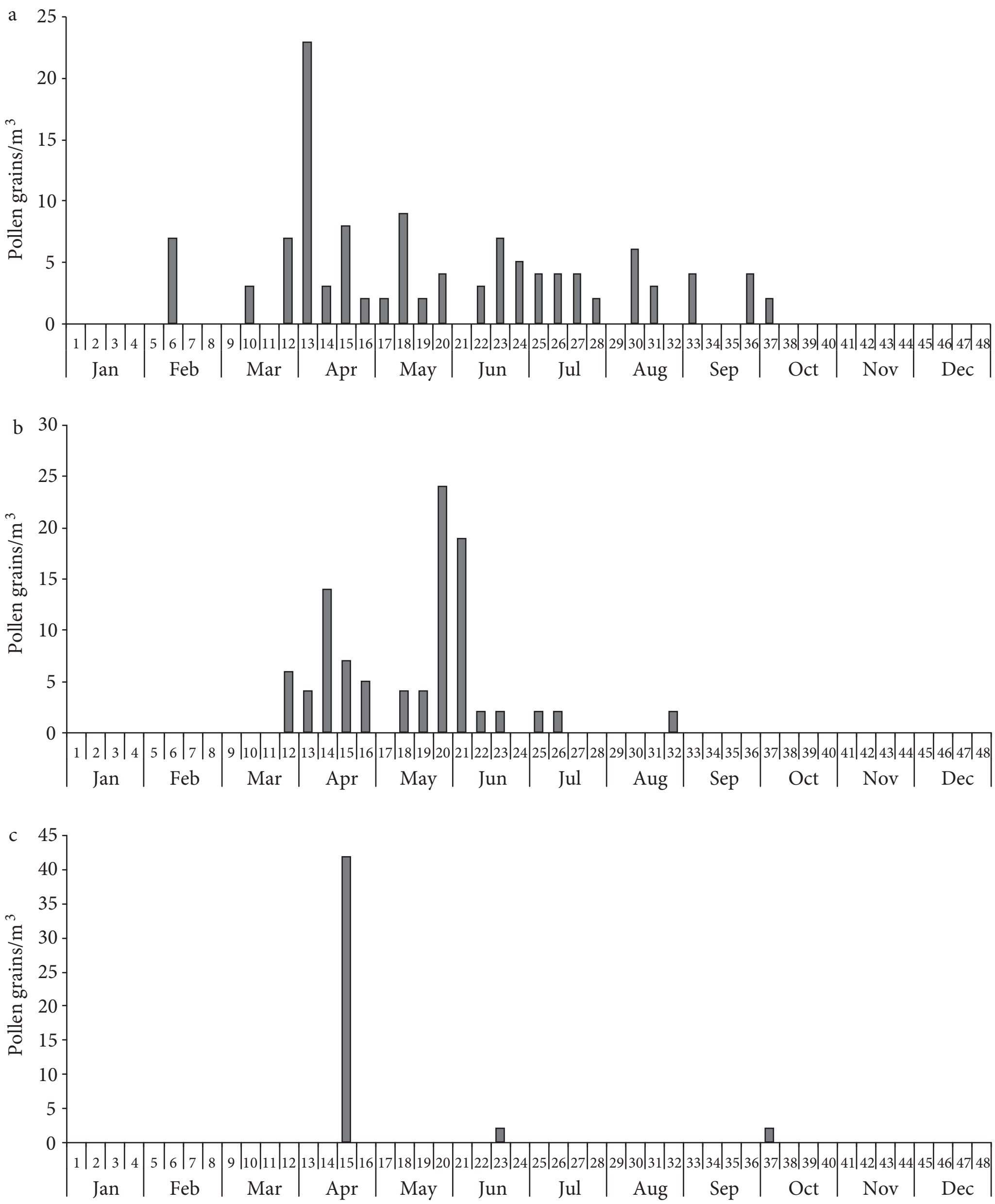

Figure 5. Weekly variations in the pollen counts of arboreal types representing more than 1% of the total pollen in the atmosphere of Konya: Betulaceae (a), Juglandacaeae (b), and *Aesculus* (c).

of April to the second week of December. The highest value was noted in the third week of August (Figure 6).

Brassicaceae pollen made up 2.49% of the total pollen with a total amount of 108 pollen grains (Table 1). The Brassicaceae pollen season started from the third week of April, reached the highest concentration in the last week of August, and ended by the first week of November (Figure 6).

Pollen grains of *Plantago* constituted about 1.66% of the total pollen and the pollen amount from this taxon was 72 (Table 1). Pollen grains of this taxon

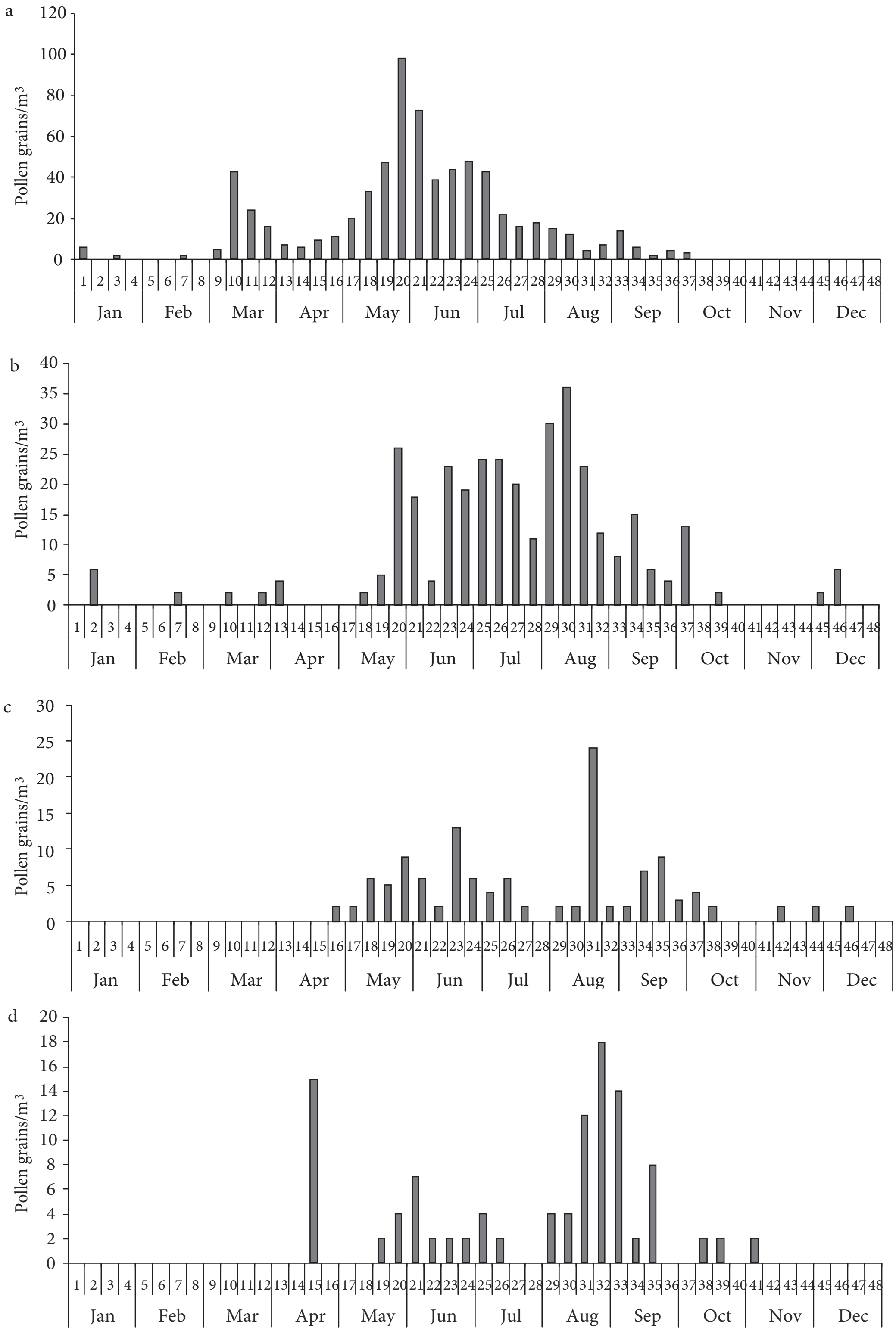

Figure 6. Weekly variations in the pollen counts of non-arboreal types representing more than 1% of the total pollen in the atmosphere of Konya: Poaceae (a), Chenopodiaceae/Amaranthaceae (b), Boraginaceae (c), and Brassicaceae (d).

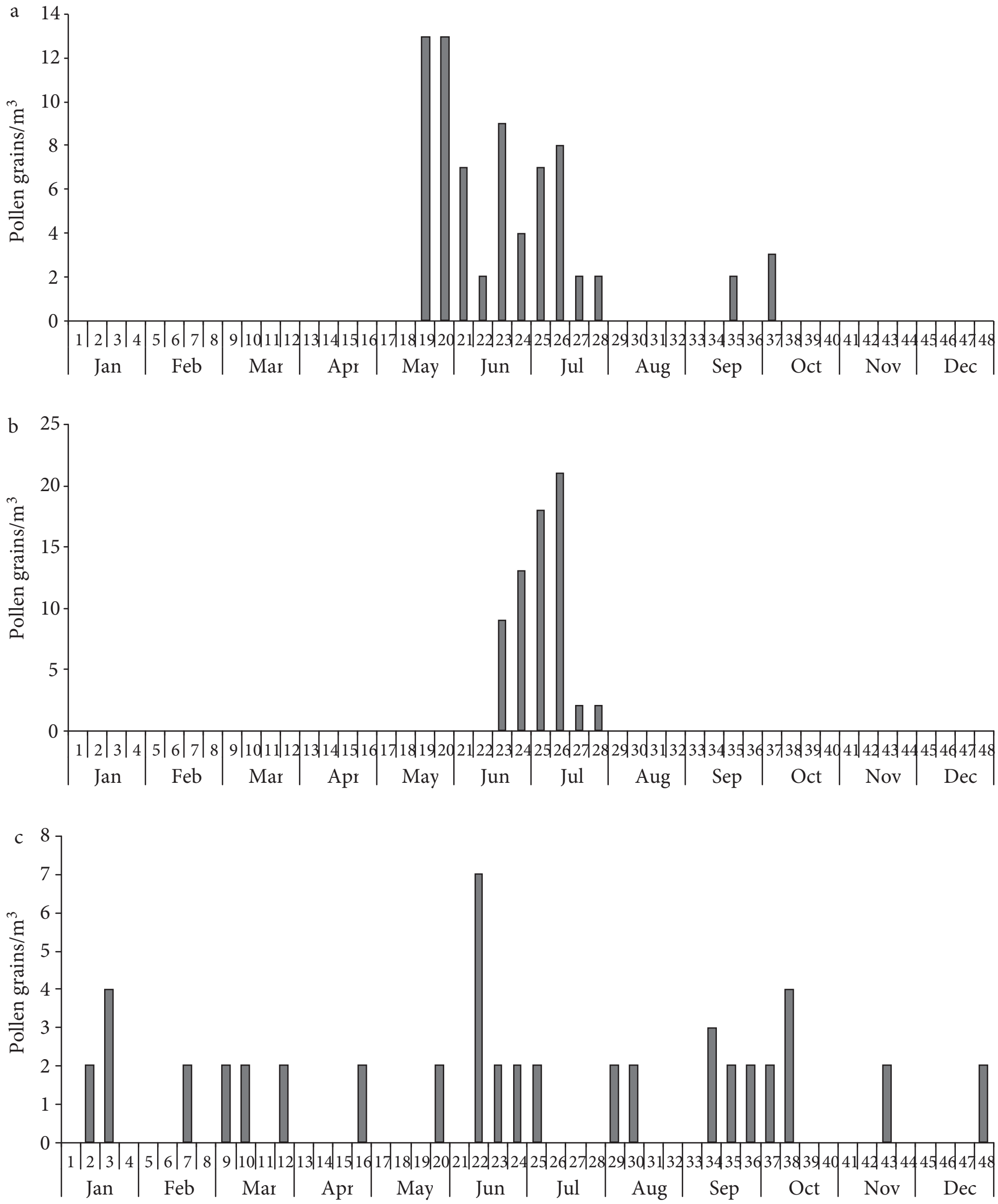

Figure 7. Weekly variations in the pollen counts of non-arboreal types representing more than 1% of the total pollen in the atmosphere of Konya: *Plantago* (a), Urticaceae (b), and Asteraceae (c).

were found in the atmosphere from the third week of May to the first week of October (Figure 7).

Pollen grains of Urticaceae were detected only in June and July. The highest Urticaceae pollen peak was recorded in the second week of July, when the non-arboreal pollen grains were very abundant in the atmosphere. The pollen amount of this genus was 65, accounting for 1.5% of the total pollen (Table 1, Figure 7).

Asteraceae represented 1.19% of the total pollen with an annual total of 52 pollen grains (Table 1). At lower concentrations, Asteraceae had a long pollen season in the atmosphere. The highest densities were recorded in June and September (Figure 7).

Table 1. Pollen taxa found in the atmosphere of Konya in 2008.

Arboreal taxa	Amount	%	Non-arboreal taxa	Amount	%
Pinaceae	1275	29.36	Poaceae	699	16.09
Fabaceae	443	10.2	Chenopodiaceae/Amaranthaceae	349	8.04
Cupressaceae/Taxaceae	360	8.29	Boraginaceae	126	2.9
Quercus	129	2.97	Brassicaceae	108	2.49
Betulaceae	118	2.72	*Plantago*	72	1.66
Juglandaceae	97	2.23	Urticaceae	65	1.5
Aesculus	46	1.06	Asteraceae	52	1.19
Morus	36	0.83	*Rumex*	36	0.83
Tilia	32	0.73	Apiaceae	22	0.51
Fraxinus	30	0.69	Campanulaceae	12	0.28
Ailanthus	22	0.51	Lamiaceae	8	0.18
Rosaceae	20	0.46	Caryophyllaceae	7	0,16
Acer	18	0.41	*Carex*	6	0.14
Salix	17	0.39	Liliaceae	6	0.14
Elaeagnus	6	0.14	Cistaceae	4	0.09
Alnus	6	0.14	*Centaurea*	4	0.09
Populus	4	0.09	Ericaceae	2	0.05
Oleaceae	3	0.07			
			Total	1578	36.34
Total	2662	61.29	Unknown	103	2.37
			Total amount (A+NA+U)*	4343	100

* A - Arboreal taxa; NA - Non-arboreal taxa; U - Unknown.

All other arboreal and non-arboreal taxa present in the samples contributed less than 1% (Table 1).

The relationships between the daily pollen amounts of the 14 taxa that contributed more than 1% of the total pollen amount and meteorological parameters (mean temperature, relative humidity, wind speed, and rainfall) in the Konya atmosphere are shown in Table 2. The pollen levels of these taxa showed significant and positive correlation with temperature whereas a significant and negative correlation was found with relative humidity, except with regard to *Aesculus* and Asteraceae (Table 2). While the pollen levels of the taxa were positively correlated with wind speed (except for *Aesculus*, Brassicaceae, and Asteraceae), they were significantly and negatively correlated with rainfall in only Cupressaceae/Taxaceae and Chenopodiaceae/Amaranthaceae among the 14 taxa (Table 2).

Discussion

In this study, pollen levels in the atmosphere of Konya in 2008 were studied by means of volumetric method using a Burkard Volumetric 7-Day spore trap. During this period, 35 pollen types were determined, 14 of which contained pollen grains making up more than 1% of the total annual pollen. The 14 taxa identified broadly reflect the local vegetation, which consists of natural steppes surrounding the city and anthropogenic formations within the city itself.

A significant percentage of the pollen in the Konya atmosphere belongs to arboreal taxa (Table 1). The high level of tree pollen is due to the fact that arboreal plants produce more pollen than non-arboreal plants. There is an abundant diversity of arboreal taxa that exist in parks, gardens, and hills. The dominance of tree pollen in the atmosphere of cities has also been noted by other previous studies (Bicakci et al., 2002;

Table 2. Correlation coefficient between daily pollen amounts of 14 taxa and meteorological parameters, based on the Spearman correlation test (*: P < 0.05, **: P < 0.01).

Taxa	Mean temperature (°C)	Rainfall (mm)	Relative humidity (%)	Wind speed (km/h)
Pinaceae	0.515**	–0.041	–0.484**	0.392**
Fabaceae	0.388**	–0.032	–0.364**	0.289**
Cupressaceae/Taxaceae	0.273**	–0.114*	–0.336**	0.211**
Quercus	0.143**	0.080	–0.142**	0.142**
Juglandaceae	0.145**	0.014	–0.196**	0.178**
Betulaceae	0.148**	0.053	–0.158**	0.189**
Aesculus	0.042	–0.051	–0.078	0.042
Poaceae	0.467**	–0.063	–0.511**	0.429**
Chenopodiaceae/Amaranthaceae	0.535**	–0.168**	–0.454**	0.278**
Boraginaceae	0.303**	0.002	–0.255**	0.177**
Brassicaceae	0.312**	–0.083	–0.241**	0.070
Plantago	0.242**	–0.053	–0.232**	0.199**
Urticaceae	0.279**	–0.083	–0.255**	0.202**
Asteraceae	0.035	0.048	–0.050	0.063

Guvensen & Ozturk, 2003; Kaplan, 2004; Kaya & Aras, 2004; Murray et al., 2008; Altunoglu et al., 2010; Ščevková et al., 2010).

Pinaceae, Fabaceae, Cupressaceae/Taxaceae, *Quercus*, Juglandaceae, and *Betula* are anemophilous trees and can produce large amounts of airborne pollen. *Aesculus* is an entomophilous taxon. Almost 56.83% of the total pollen was produced by trees introduced either for ornamental purposes (Pinaceae, Fabaceae, Cupressaceae/Taxaceae, *Quercus*, *Betula*) or economic reasons (Juglandaceae). Many aeropalynological studies in Turkey and other countries have reported that the pollen amounts of these taxa are dominant in relation to other arboreal taxa (Ciancianaini et al., 2000; Altintaş et al., 2004; Al-Qura'n, 2008; Altunoglu et al., 2010).

Poaceae, Chenopodiaceae/Amaranthaceae, Boraginaceae, Brassicaceae, *Plantago*, Urticaceae, and Asteraceae are synanthropic and ruderal and their pollen represented 33.87 % of the total found in the atmosphere of Konya. All of these taxa are anemophilous taxa, except for Boraginaceae and Brassicaceae. In general, the pollen seasons of these taxa have a long duration in Konya due to the diversity of their species (i.e. each taxon has a specific flowering period). Several researchers have also found the pollen grains of these taxa to be more intense than other non-arboreal taxa in the atmosphere of their studied fields (Bicakci & Akyalcin, 2000; Guvensen & Ozturk, 2003; Türe & Salkurt, 2005).

Among all of the meteorological parameters analysed in this study, the daily pollen levels of the 14 most prominent taxa were generally found to be positively correlated with temperature and wind speed (Table 2). Many researchers have reported that there has been significant and positive correlation between the pollen amounts of different taxa and temperature (Riberio et al., 2003; Gioulekas et al., 2004; Alwadie 2008). Temperature acts on the vegetative growing, setting, and ripening of different plant organs and on the productivity of the plant itself (Avolio et al., 2008). Our results related to the correlation between daily pollen amount and wind speed showed similarities with results reported earlier (Damialis et al., 2005; Pérez-Badia et al., 2010). Wind speed plays an important role in the dispersion of bioparticles. By blowing at speeds greater than 10 km/h for most of the year, wind rapidly moves the pollen grains away from the source of emission and from the different layers of the atmosphere (Ballero & Maxia, 2003; Damialis et al., 2005). The correlation between daily pollen amounts and relative humidity was negative (Table 2), a finding that was also supported by the results of previous studies (Boral et al., 2004; Sahney

& Chaurasia, 2008). High environmental humidity inhibits the opening of anthers and makes pollen heavier, thereby preventing the pollen grains from remaining suspended in air (Sahney & Chaurasia, 2008). In this study, there was a negative significant correlation between pollen amounts and rainfall in only Cupressaceae/Taxaceae and Chenopodiaceae/Amaranthaceae among the 14 major taxa (Table 2). This can be caused by an event known as "rain washing," a phenomenon that reduces the air pollen concentration by passively dragging the bioparticles to the ground (Aira, 2001; Ballero & Maxia, 2003; Sahney & Chaurasia, 2008).

Pollen is a significant issue from a human health perspective. It has been known to trigger allergic respiratory diseases such as asthma and allergic rhinitis. Pollen grains of Cupressaceae (Negrini & Arobba, 1992; Barletta et al., 1998; Dubus et al., 2000; Di Felice et al., 2001), *Quercus* (Negrini & Arobba, 1992; Ross et al., 1996; De Benito Rica & Soto Torres, 2001), Betulaceae (Obtulowiez et al., 1991; Negrini and Arobba, 1992; De Benito Rica & Soto Torres, 2001; Kihlström et al., 2003), *Aesculus* (Popp et al., 1992), Chenopodiaceae/Amaranthaceae (Galán et al., 1989; Negrini & Arobba, 1992; De Benito Rica & Soto Torres, 2001), Poaceae (Obtulowiez et al., 1991; De Benito Rica & Soto Torres, 2001), *Plantago* (Obtulowiez et al., 1991; De Benito Rica & Soto Torres, 2001), Urticaceae (De Benito Rica & Soto Torres, 2001), and Asteraceae (Obtulowiez et al., 1991; Negrini & Arobba, 1992; De Benito Rica & Soto Torres, 2001) are important allergenic pollen grains. We think that the findings obtained from this study can help allergy doctors diagnose, treat, and follow up on patients suffering from allergic pollen diseases.

Acknowledgement

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