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Research Article

Analysis of Airborne Pollen Grains in Kayseri, Turkey

Kayseri İli Atmosferik Polenlerinin Analizi

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Abstract

In this study, pollen grains of the province of Kayseri atmosphere were collected by using a Burkard Volumetric 7-Day spore trap from January 2011 to December 2011. Plant taxa of pollen grains were identified. A total of 2.698 pollens/m3 belonging to 46 taxa were observed during 2011 in Kayseri. Pollen grains of Pinaceae, Cupressaceae / Taxaceae, Betulaceae, Platanus, Acer, Quercus, Moraceae, Rosaceae, Poaceae and Artemisia were found as dominant arboreal and non arboreal pollen types in Kayseri. The highest monthly pollen counts were observed in June. Daily average pollen counts from the ten most frequently recorded pollen taxa in their pollen season were entered into Spearmens's correlation analysis with meteorological data. The data obtained from this study will be guiding the protection of sensitive pollen allergic patients living in the densely populated cities as Kayseri. Knowing when the pollen season and the amount of pollen grains in the atmosphere will make it easier to take preventive measures of patients.

Keywords: Airborne pollen, Atmosphere, Burkard trap, Kayseri, Meteorological factors, Turkey

Öz

Bu çalışmada, Kayseri ili atmosferik polenleri 1 Ocak 2011 - 31 Aralık 2011 tarihleri arasında bir yıl süreyle Burkard Tuzağı ile toplanmıştır. Kayseri ilinde 2011 yılında 46 farklı taksona ait 2698 polen/m3 tespit edilmiştir. Pinaceae, Cupressaceae / Taxaceae, Betulaceae, Platanus, Acer, Quercus, Poaceae ve Artemisia polenleri dominant olarak bulunmuştur. En yüksek polen konsantrasyonu Haziran ayındadır. En sık rastlanan on taksonun polen sezonlarına ait günlük polen verilerine meteorlojik faktörlerin etkisi Spearman Korelasyon testi ile ölçülmüştür. Bu çalışmadan elde edilen veriler Kayseri gibi nüfusu yoğun illerde yaşayan alerji hastalarının alerjiden korunmasına yardımcı olacaktır. Ayrıca polen sezonunun ve atmosferdeki polen konsantrasyonunun bilinmesi hastaların önlem almasını kolaylaştıracaktır.

Anahtar Kelimeler: Airborn polen, Atmosfer, Burkard tuzağı, Kayseri, Meteorolojik faktörler, Türkiye

1. Introduction

Pollen grains are among the allergens groups of atmosphere. They are presented in the atmosphere most of the year depending on the pollination periods of plants. Airborne pollens has importance in applications for systematics, agriculture, forest studies and also, especially, for protection and treatment of sensitive inviduals. Pollen grains are the main agents those cause asthma and rhinoconjuctivitis all over the World (Bousquet et al. 1984, Spieksma et al. 1989, D'amato et al. 1991). According to recent researches, the prevelance of pollen allergy in Europe is estimated to be about %40 (D'amato et al. 2007). Some studies have analysed the relationship between airborne pollen concentrations and allergy in Turkey (Altıntas et al. 2004, Çelik et al. 2004, Dursun et al. 2008).

The pollen content of atmosphere varies according local flora, climate, meteorological factors and the season (Emberlin et al. 1997, Jato et al. 2002, Pınar et al. 2004, Jato et al. 2009, Gioulekas et al. 2004, Çeter et al. 2011). Therefore, knowledge on airborn pollen is very important, particularly in the atmosphere of highly populated cities. To describe the seasonal variations in pollen recorded at the locations, pollen calendars have been published for different cities in Turkey (Aytuğ 1974, Ince 1994, Inceoğlu et al. 1994, Bıçakçı et al. 1996, 2000, 2002, Pınar et al. 1999, Güvensen and Öztürk 2002, Kaplan 2004, Potoğlu Erkara

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et al. 2008, Çeter et al. 2011, Öztürk et al. 2013, Tosunoğlu et al. 2015) As a first step the main aim of this research is to study seasonal pollen grains, and to make quantitative and qualitative analysis of pollen fall belonging to arboreal and non-arboreal taxa in the Kayseri atmosphere by volumetric sampling. The annual pollen concentration results of region presented in this paper may be useful for allergologists to establish an exact diagnosis.

2. Material and Methods

2.1. Site Information

Kayseri is situated in the Inner Anatolian Region (near Cappadocia) of Turkey at an altitude 1,093 meters, at 38°45' N, 35°29' E. Kayseri is part of the Irano-Turanian floristic region (Çetik 1982). The main flora of province is steppe vegetation which is nurtured by the arid and semiarid aspects of the Mediterranean climate, which is a dry sub-humid climate with little or no water surplus. About 40% area of the province is used for agricultural, the lowest ratio of land area is forest and heathland, consisting of species such as *Juniperus oxycedrus* L. and *Juniperus excelsa* Bieber. from the Cupressaceae family, and *Quercus pubescens* Wild. and *Quercus cerris* L. from the family Fagaceae is located as Cypress and Oak forests in the province. In addition, there are three mountain, named Erciyes (highest mountain in Central Anatolia), Ali and Yılanlı, around the city where the plants diversity is high, some of them are *Abies cilicica.* subsp. *cilicica, Cedrus libani* L., *Pinus sylvestiris* L., *P. nigra* J.F.Arnold., *Juniperus communis* L. *subsp. nana, J. oxycedrus* L. *subsp. oxycedrus, J. foetidissima* (Willd.), *Thuja orientalis* L., *Rumex acetosella* L , *Chenopodium botrys* L., *Salsola ruthenica* (Iljin.), *Amaranthus retroflexus* L., *A. albus* L., *Hypericum lydium* (Boiss.), *Ailanthus altissima* (Mill.), *Acer platanoides* L., *Vitis vinifera* L., *Rhamnus petiolaris* (Boiss.), *Rhus coriaria* L., *Parietaria judaica* L., *Morus alba* L., *Ulmus minör* L., *Juglands regia* L., *Quercus robur, Q. pubescens* (Willd.), *Ostrya carpinifolia* (Scop.), *Salix alba* L., *Populus alba* L., *Bromus cappadocicus* (Boiss. & Balansa), *Avena sativa* L., *Lolium perene* L., *Poa pratensis* L., *P. bulbosa* L., *Dactylis glomerata* L., *Stipa holosericea* (Trin.), *Cynodon dactylon* L., *Sorghum halegense* L., *ve Zea mays* L. (İnce et al. 2004).

2.2. Aeropalynological Survey

Pollen data were collected using a 7-day recording volumetric Burkard spore trap during 2011. The trap was placed on the roof of the Safiye Çıkrıkçıoğlu Technical College building in the centre of Kayseri at a height of 7 m above ground level (Figure 1). Atmospheric sampling and analysis followed the method described by the Spanish Aerobiological Network (REA) (Gala´n et al. 2007) and the minimum requirements of EAN (Gala´n et al. 2014). Pollen counts were converted into daily average concentrations (pollen grains/m^3). Characteristics of the pollen season for most dominant 10 taxa in Kayseri province was given in Table 1. For these taxa, the start and end of the pollen season was defined on the basis of the flowering intensity and flowering behaviours of the taxa below:

- For Cupressaceae / Taxaceae, *Quercus*, *Acer*, *Platanus*, Moraceae and Rosaceae: Start = 1 pollen grain/m^3 + 5 days with 1 or more pollen grains/m^3 ; End = 1 pollen grain/m^3 + 5 days with counts below this level.

Figure 1. Location map of the volumetric spore trap in Kayseri.

- Pinaceae: Start >20; End < 20
- Poaceae, Amaranthaceae and Betulaceae: Start > 10; End < 10

2.3. Meteorological Data

Mean daily and monthly meteorological data (mean daily temperature, relative humidity, precipitation and wind speed) were obtained from the Turkish State Meteorological Service located at Ankara (Figure 2).

3. Results and Discussion

During the study year, the average temparature was 10,3 °C, while the average temparature for long term period (1960-2011) in Kayseri was 10,5°C. The warmest month was July in 2011.The annual average rainfall for the period 1960-2012 was 32,5 mm. However over the study period the annual average rainfall was 40,85 mm. and the annual average humidty was 61,1%. The wettest month was June in 2011 (Figure 2).

Table 1. Characteristics of the pollen season for most dominant 10 taxa in Kayseri province

	Pinaceae	Poaceae	Cupr/Tax	Betulaceae	Amaranthaceae
peak value (pollen/m^3)	43	44	25	118	13
peak day	4th June	15th June	19th March	25th March	4th July
pollen season date	14/4-17/7	11/5-11/8	8/3-10/7	10/1-18/5	21/6-15/9
pollen index (pollen/season)	10381	5244	4081	3490	2178
season length (days)	95	93	125	129	87
pollen season date	***Platanus***	***Acer***	***Quercus***	**Moraceae**	**Rosaceae**
peak value (pollen/m^3)	25	18	9	6	3
peak day	4th May	4th April	25th May	19th May	8th April
pollen season date	4/4-23/5	25/3-18/4	4/4-7/6	4/5-4/6	7/4-23/6
pollen index (pollen/season)	2861	1857	1178	625	372
season length (days)	50	25	65	32	78

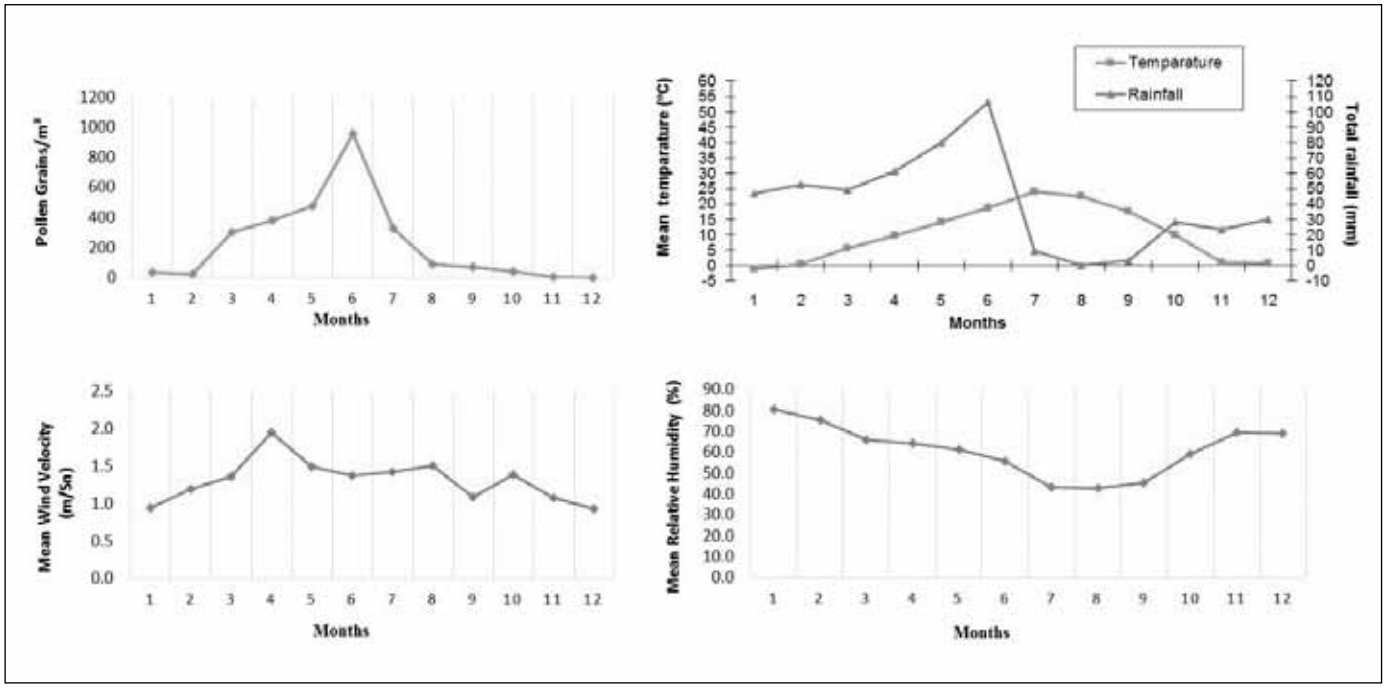


Figure 2. Monthly variations in atmospheric pollens grains and meteorological conditions in the atmosphere of Kayseri, 2011.

In the atmosphere of Kayseri, a total of 38843 pollen grains (2698 pollen grains per m^3) from 46 plant taxa were determined in 2011. During the study period maximum quantity of pollen grains were recorded in June with 959 pollen grains per m^3. Over the one-year study period, pollen grains from arboreal taxa were the largest contributors to the airborne catch (75,27 %), followed by grasses (Poaceae) (14,39%) and the non arboral (10,34 %) (Figure 3). In addition, just ten pollen types made up 87% of total amount of pollen recorded in the atmosphere of Kayseri, Pinaceae (27,73%), Poaceae (14,38%), Cupressaceae / Taxaceae (10,9%), Betulaceae (9,76%), *Platanus* (7,37%), Amaranthaceae (6,07%), *Acer* (4,8%), *Quercus* (3,09%), Moraceae (1,7%) and Rosaceae (1,26%) (Table 2).

The earliest pollen releasing to Kayseri atmosphere were noted in January. Main arboreal pollen grains of Cupressaceae/Taxaceae, *Betula*, *Alnus*, and *Corylus* were observed during this month in small amounts. Number of pollen grains started to increase in February, March, April and reached the highest level in June. Lower rainfall and humidity and higher temparature and wind speed contributed to increasing pollen concentration in May and June. Pollen grains of Cupressaceae/Taxaceae and Betulaceae taxa were at high levels in March. *Platanus* and *Acer* sp. disperse high amount of pollen into the Kayseri atmosphere during their pollination periods in April. Pollen grains of *Pinus*, *Quercus* and Moraceae reached high level in May. In June, number of pollen grains was still at highest

Table 2. Annual percentage values of pollen counts, Kayseri 2011

Taxa	Annual total pollen count	Pollen count (%)	Taxa	Annual total pollen count	Pollen count (%)
Acacia	16	0.04	*Salix*	384	0.99
Acer	1864	4.80	*Sambucus*	8	0.02
Aesculus	36	0.09	*Tilia*	11	0.03
Ailanthus	123	0.32	*Ulmus*	63	0.16
Alnus	56	0.14	*Vitis*	5	0.01
Apiaceae	455	1.17	Poaceae	5587	14.38
Betulaceae	3792	9.76	*Artemisia*	257	0.66
Corylus	106	0.27	Asteraceae	2355	0.89
Cupressaceae/Taxaceae	4182	10.90	Boraginaceae	14	0.04
Ericaceae	163	0.42	Brassicaceae	179	0.46
Fabaceaee	445	1.09	*Carex*	22	0.06
Fagus	26	0.07	Caryophyllaceae	12	0.03
Fraxinus	354	0.91	Amarantaceae	2358	6.07
Juglans	418	1.08	*Galium*	35	0.09
Magnolia	13	0.04	*Humulus*	12	0.03
Moraceae	662	1.70	Lamiaceae	77	0.20
Myrtaceae	22	0.06	Liliaceae	9	0.02
Oleaeceae	245	0.63	Papaveraceae	37	0.30
Pinaceae	10770	27.73	*Plantago*	118	0.64
Platanus	2862	7.37	Ranunculaceae	250	0.02
Populus	430	1.11	*Rumex*	6	0.40
Quercus	1202	3.09	*Typha*	157	0.02
Rosaceae	488	1.26	Urticaceae	7	0.40

levels. Pinaceae and Poaceae make important contribution to the total pollen number in this month. Cupressaceae, *Ailanthus*, Rosaceae and Oleaceae were other important arboreal contributors and Urticaceae, Chenopodiaceae/ Amaranthaceae, Asteraceae, *Plantago*, *Rumex*, Apiaceae, Brassicaceae and Fabaceae were non-arboreal contributor to the pollen number in June. In July, high levels of pollen grains in Chenopodiaceae /Amaranthaceae were observed.

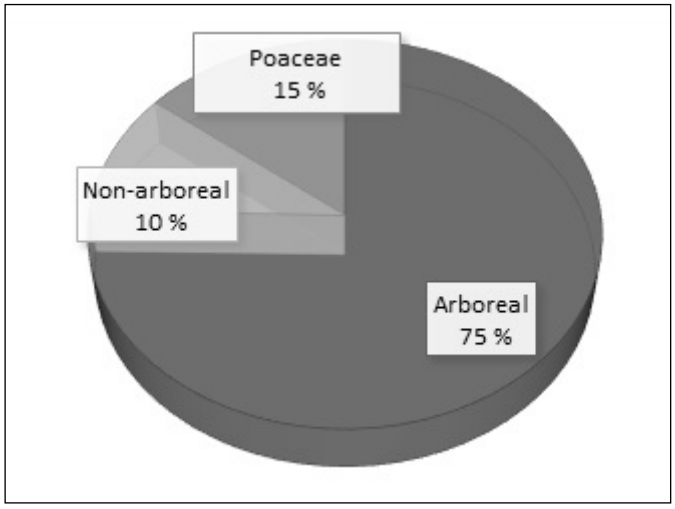
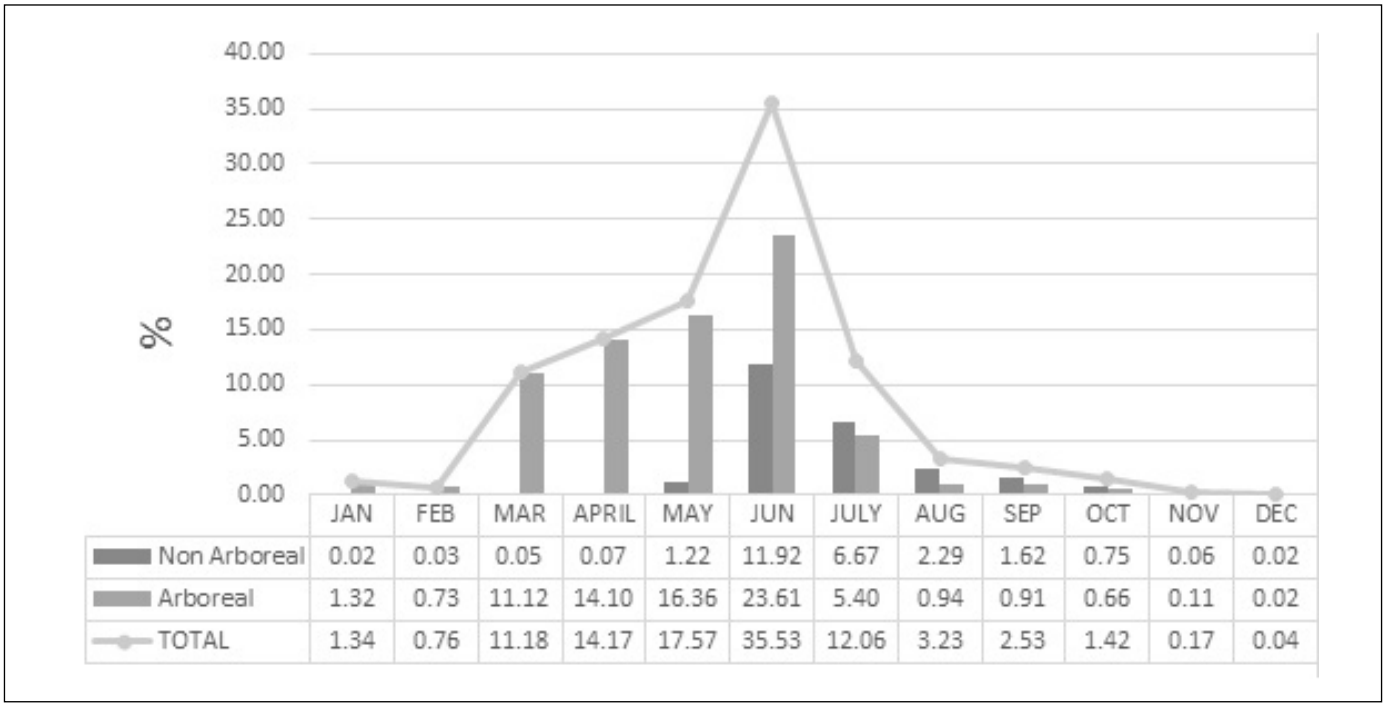


Figure 3. Pollen from three groups presented as a percentage of the total pollen amount of pollen recorded during the year of 2011 at Kayseri.

Pinaceae and Poaceae are still major contributors to the pollen amount in July. In August, Amaranthaceae, Pinaceae, Poaceae, Papaveraceae and Ericaceae were dominant in the atmosphere of Kayseri. In November, low quantities of *Cedrus* pollen grains were recorded. The amount of pollen grains in Kayseri atmosphere was very low in December because of higher rainfall levels and lower temparatures than the other months. Pinaceae and Cupressaceae/Taxaceae pollen grains were recorded at lower levels in December (Table 1, Figures 4, 5 and 6).

The following fourteen taxa produced the highest (more than 1%) amount of pollens in the atmosphere of Kayseri during the period (Figure 4, Table 2). *Pinaceae:* Pollen grains were recorded during the greater part of the year, from January to December. The main pollen season began in the second week of April and ended in the third week of July. The maximum counts was recorded in the first week of June. Poaceae: The pollen season started at the second week of May and ended in the second week of August. The maximum counts was recorded in the second week of June. Cupressaceae / Taxaceae: The pollen season of these families started at the second week of March and ended in the second week of July. The highest counts was recorded in the third week of March. Betulaceae: The pollen season began in the second week of January and ended in the third week of May. The maximum counts was recorded in the last week of March.



	JAN	FEB	MAR	APRIL	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC
Non Arboreal	0.02	0.03	0.05	0.07	1.22	11.92	6.67	2.29	1.62	0.75	0.06	0.02
Arboreal	1.32	0.73	11.12	14.10	16.36	23.61	5.40	0.94	0.91	0.66	0.11	0.02
TOTAL	1.34	0.76	11.18	14.17	17.57	35.53	12.06	3.23	2.53	1.42	0.17	0.04

Figure 4. Annual percentage of arboreal, non-arboreal pollen grains recorded in Kayseri atmosphere.

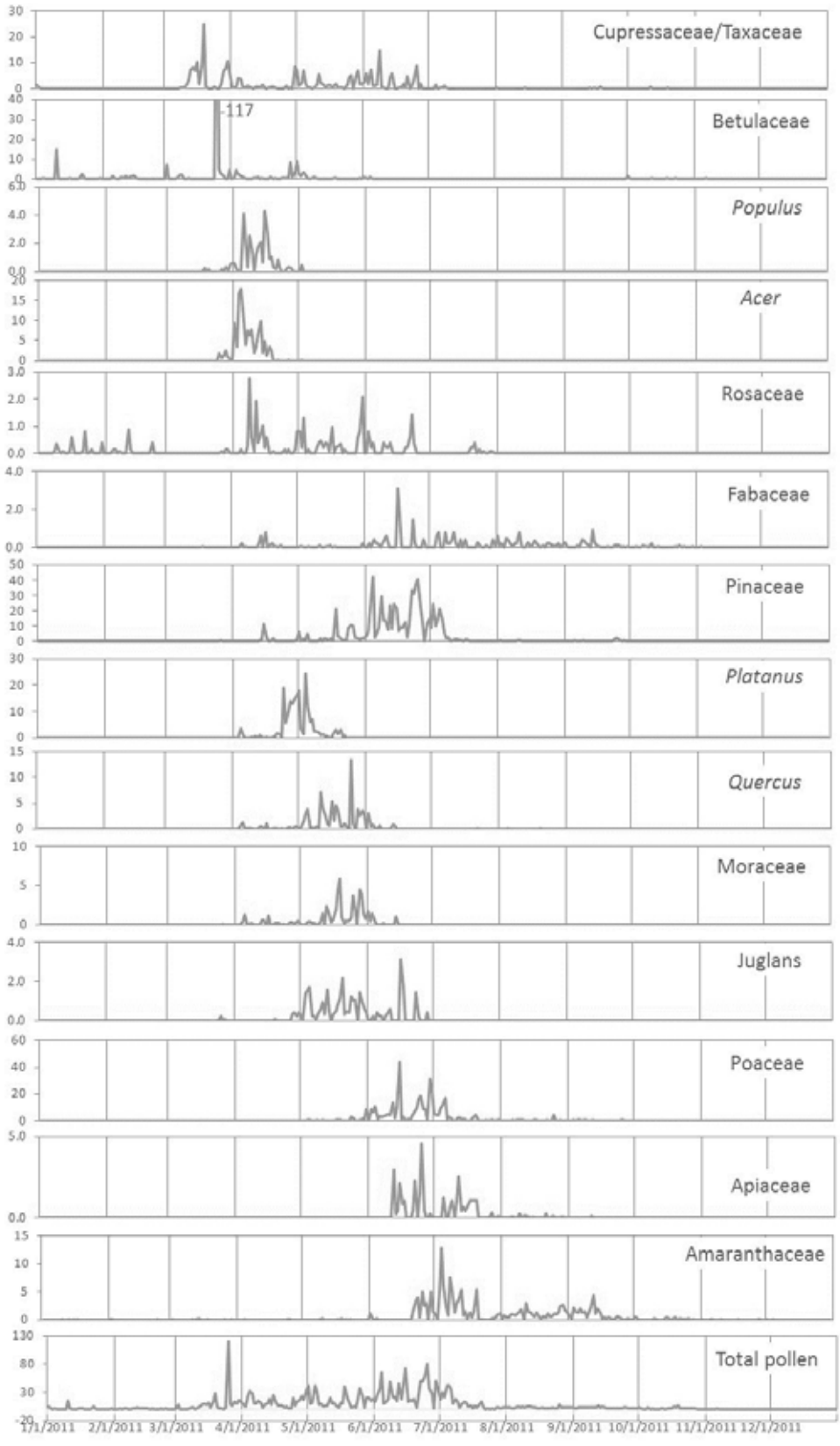


Figure 5. Daily pollen concentrations (pollen/m^3) recorded in Kayseri (Jan 2011-Dec 2011).

Platanus: Pollen release started in the first week of April and ended in the last week of May. The maximum counts was recorded in the first week of May. Amaranthaceae: The pollen season started at the last week of June and ended in the middle of September. The maximum counts was recorded in the first week of July. Acer: The pollen season began in the last week of March and ended in the third week of April. The highest concentrations was recorded in the first week of April. *Quercus*: The pollen season began in the first week of April and ended in the first week of June. The maximum counts was recorded in the last week of June. Moraceae: The pollen season began in the first week of May and ended in the first week of June. The maximum counts was recorded in the third week of May. Rosaceae: The pollen season began in the first week of April and ended in the last week of June. The maximum counts was recorded in the second week of April.

The relationships between the daily pollen amounts of the 10 taxa that contributed more than 1% of the total pollen amount and meteorological parameters (mean temperature, relative humidity, wind speed, and rainfall) in Kayseri atmosphere are shown in Table 3. According to Spearmen's correlation analysis, relations between taxa and meteorological factors quite vary. The pollen levels of Pinaceae, Betulaceae, *Quercus* and Moraceae showed significant and positive correlation with temperature whereas a significant and negative correlation was found to Amaranthaceae (95% probability). For pollen grains of Pinaceae, there was a significant negative correlations with rainfall and relative humidity (99% probability). For pollen grains of Betulaceae there was a significant positive correlations with mean temperature (95% probability) whereas a significant negative correlations with relative humidity. (95% probability). For pollen grains of *Acer* were positively correlated with daily total rainfall. While the pollen levels of *Quercus* were positively correlated with mean daily temparature (99% probability) , they were significantly and negatively correlated relative humidty (95% probability). For pollen grains of Moraceae there was a significant positive correlation with mean daily temperature (95% probability). There were no correlation between taxa and wind speed was observed.

During study period, 46 pollen types were determined, 10 of which contained pollen grains making up 87,06% of the total annual pollen. In the atmosphere of Kayseri, arboreal pollen types were dominant; this is due to the character of vegetation and geographical location of the town. Arboreal pollen types are also dominant not only in close cities to the research area in Turkey, i.e. 85% in Kastamonu (Çeter et al. 2011), 81% in Eskişehir (Erkara et al. 2008), 90% in Sivrihisar (Erkara 2007), 79% in Bozüyük (Türe and Şalkurt 2005), 83% in Kütahya (Bıçakçı et al. 1999), 79% in Bursa (Bıçakçı et al. 2003), 70% in Sakarya (Bıçakçı 2006), 80% in Ankara (Pınar et al. 1999), but also some countries in Europe, i.e. 69.7% in Thessaloniki, Greece (Damialis et

Table 3. The results of Spearman's correlation analysis between daily average pollen counts of selected ten dominant taxa and meteorological data

Pollen Types	Mean Daily Temparature	Daily Total Rainfall	Mean Daily Relative Humidty	Mean Daily Wind Speed
Pinaceae	0,521**	-0,318**	-0,437**	-0,114
Poaceae	-0,073	-0,058	-0,028	-0,060
Cupressaceae/Taxaceae	0,009	-0,171	-0,116	-0,057
Betulaceae	0,178*	-0.038	-0,178*	0,021
Amaranthaceae	-0,257*	-0,123	0,121	0,008
Platanus	0,125	0,080	0,232	-0,007
Acer	-0,041	0,412*	0,294	0,206
Quercus	0,423**	-0,143	-0,279*	-0,075
Moraceae	0,354*	0.171	-0.203	0.013
Rosaceae	0,068	-0,018	-0,145	-0,033

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level (2-tailed).

al. 2005), 82,0% in Finland (Koivikko et al. 1986), 55,0% in Ascoli Piceno, Italy (Romano et al.1988) and 73,0% in Ostrawiec Swietokryzyski, Poland (Kasprzyk 1996).

İnce et al. (1994), observed pollen of 43 taxa in the atmosphere of Kayseri by gravimetric method (Durham's sampler). The most important pollen taxa identified were the trees Pinaceae,

Cupressaceae/Taxaceae, *Populus* and *Quercus*, as well as Poaceae and the weeds Chenopodiaceae/Amaranthaceae. Kızılpınar et al. (2012) also used gravimetric method to study atmospheric pollen grains in Konya. The researchers found 35 taxa, of which 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%. In Kastamonu, located in the west side of the Black Sea region of Turkey, Çeter et al (2011), observed 51 taxa in two-year study period. Pollen grains from woody perennials were the largest contributors to the airborne catch (85,4%), followed by Poaceae (9,7%) and then weeds (4,9%). Pınar et al. (1999) studied atmospheric pollen grains in Ankara. They observed 44 pollen taxa in the atmosphere. According to their study, the highest concentrations of pollen grains were recorded in June.

In this study, ten dominant taxa (Pinaceae, Poaceae, Cupressaceae/Taxaceae, Betulaceae, *Platanus*, Amaranthaceae, *Acer*, *Quercus*, Moraceae and Rosaceae) comprised the majority (87,06%) of the total amount of pollen recorded at Kayseri. However, the dominance of these taxa can vary temporal and spatially. For example, in previous studies carried out in Turkey, such as Denizli (Güvensen et al.2013), the dominant taxa were also recorded as being Pinaceae (24.19%), Cupressaceae/Taxodiaceae (15.99%) and *Olea europaea* (11.35%). The pollen spectrum recorded at Kayseri generally relates well to the local flora and vegetation of the area. *Betula* and *Corylus* (Betulaceae) taxa are not the part of the local flora at Kayseri, however high atmospheric pollen counts of Betulaceae result from planting trees in parks, gardens and alongside the roads in Kayseri (particularly *B. pendula* and *C. avellana*). During the study period, some important allergenic pollens of certain plants like Poaceae, Cupressaceae /Taxaceae, Betulaceae, *Platanus* sp., *Acer* sp., Moraceae, Amaranthaceae and *Artemisia* sp. were found. Among these allergic pollen releasing plants, some groups such as Poaceae (Chapman 1986, Suphioğlu et al. 1998, De Benito Rica & Soto Torres, 2001, Ruden and Steinman 2004), Cupressaceae (Leventin and Buck 1980, Bousquet et al. 1984, Spieksma 1990, Dubus et al., 2000, Di Felice et al. 2001, Guardia et al. 2006, D'amato et al. 2007), Amaranthaceae (Leventin and Buck 1980, Chapman 1985, Galan et al. 1989, Colás et al. 2005), and Asteraceae (Lewis and Vinay 1979, Aytuğ et al. 1990, Zwander 2001) are more important than the most other plants because of long pollination period and strong allergic effects (heyfever, pollinosis, asthma, etc.). In addition, pollen grains belong to Betulaceae family are also among important allergic triggers that cause asthma, allergic rinit and conjuctivitis (Milkowska et al. 2006). Betulaceae taxa are widespread in north, central and eastern Europe. Especially Betulaceae members such as *Alnus, Betula a*nd *Corylus* are located naturally in north side of Turkey and are widespread in parks and gardens as cultivars. They have high pollen production in their main pollen season and Betulacaee pollens exist in skin prick tests in Turkey as well as in Europe. *Platanus orientalis* is generally planted in large numbers in the city centre as well as in parks and gardens for landscape architectural purposes. It's reported that there are also cross reactivity between Poaceae, *Betula*, *Olea europaea, Artemisia*, Chenopodiaceae and *Platanus* sp. (Asturias et al. 2002). The prevalence of allergy to *Platanus* is currently moderate, although the percentage of monosensitized patients is low (Fernandez Gonzalez et al.2010). Also, the prevalence of allergy to *Acer* and Moraceae are moderate, too (Levetin and Buck 1980, Chapman 1986).

4. Conclusion

This study presents the first detailed investigation of meteorological variations in atmospheric pollen for Kayseri by volumetric sampling. Four of the ten most dominant taxa in the atmosphere of Kayseri are considered to be highly allergenic (Poaceae, Cupressaceae/Taxaceae Betulaceae and Amaranthaceae). Information obtained from these kinds of studies will help us to determine both the knowledge of the distribution mechanisms of pollens and minimizing the negative effect on the health of pollen sensitive people in densely populated cities as Kayseri. A one year aeropalynologıcal study presented in this paper may be useful for allergologists and visitors in timing their visit to the city and people living in Kayseri province. Also it will help understanding the biological-behavior of pollen grains in the atmosphere.

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