http://dergipark.gov.tr/trkjnat
Trakya University Journal of Natural Sciences, 19(2): 137-146, 2018
ISSN 2147-0294, e-ISSN 2528-9691
DOI: 10.23902/trkjnat.402912

Research Article

ANALYSIS OF ATMOSPHERIC POLLEN GRAINS IN DURSUNBEY (BALIKESİR), TURKEY

Hanife AKYALÇIN[1], Aycan TOSUNOĞLU[2*], Adem BIÇAKÇI[2]

[1] 18 Mart University, Faculty of Science & Arts, Department of Biology, Çanakkale, TURKEY
[2] Uludağ University, Faculty of Science & Arts, Department of Biology, Bursa, TURKEY
ORCID ID: orcid.org/0000-0003-2303-672X
*Corresponding author: e-mail: aycanbilisik@uludag.edu.tr

Cite this article as:

Akyalçın H., Tosunoğlu A. & Bıçakçı A. 2018. Analysis of Atmospheric Pollen Grains in Dursunbey (Balıkesir), Turkey. *Trakya Univ J Nat Sci*, 19(2): 137-146, DOI: 10.23902/trkjnat.402912

Received: 07 March 2018, Accepted: 03 September 2018, Online First: 11 September 2018, Published: 15 October 2018

Abstract: In this study, airborne pollen grains in the atmosphere of Dursunbey (Balıkesir, Turkey) were collected using a gravimetric method. The pollen grains were investigated by light microscopy and a total of 6265 pollen grains per cm^2 were counted. 42 different pollen types were identified of which 24 belonged to the arboreal plants (86.17% of the annual pollen index) and 18 to non-arboreal plants (13.16% of the annual pollen index). A small portion of the pollens (42 grains, 0.67%) were not identified. The most frequent pollen types, which constituted more than 1% of annual pollen count were regarded as the predominating pollen types for the region. The predominating group was determined to be consisted of pollens of *Pinus* L. (48.23%), Cupressaceae Rich. ex Bartl./Taxaceae Gray (16.74%), Poaceae Barnhart (8.32%), *Quercus* L.(5.31%), *Acer* L. (4.07%), *Platanus* L. (3.10%), *Juglans* L. (2.26%), *Abies* Mill. (1.75%), *Plantago* L. (1.25%), Amaranthaceae Juss. (1.22%) and *Olea europaea* L. (1.16%). The highest pollen count was determined in May and it is striking that most of the determined predominant pollen types have previously been reported as main causes of pollinosis.

Key words: Pollen fall, atmospheric monitoring, gravimetric method, pollen calendar, allergy.

Özet: Bu çalışmada, Dursunbey (Balıkesir, Türkiye) atmosferindeki polenler gravimetrik yöntem kullanılarak toplanmıştır. Toplanan polenler ışık mikroskobu ile incelenmiş ve cm^2 başına toplam 6265 polen sayılmıştır. 24 tanesi odunsu bitkilere (yıllık polen indeksinin % 86,17'si), 18 tanesi ise otsu bitkilere (yıllık polen indeksinin %13,16'sı) ait olan toplam 42 farklı polen tipi tanımlanmıştır. Polenlerin az bir kısmı ise (42 polen, %0.67) tanımlanmamıştır. Sıklıkla rastlanılan ve yıllık toplam polen sayısının %1'inden fazlasını oluşturan polen tipleri bölge için dominant polen tipleri olarak kabul edilmiş olup *Pinus* L. (%48,23), Cupressaceae Rich. ex Bartl./Taxaceae Gray (%16,74), Poaceae Barnhart (%8,32), *Quercus* L. (%5,31), *Acer* L. (%4,07), *Platanus* L. (%3,10), *Juglans* L. (%2,26), *Abies* Mill. (%1,75), *Plantago* L. (%1,25), Amaranthaceae Juss. (% 1,22) ve *Olea europaea* L. (%1,16) polenleri atmosferik polen spektrumunun ana bileşenleri olarak kaydedilmiştir. Atmosferdeki en yüksek polen miktarı Mayıs ayında tespit edilmiş olup, belirlenen dominant polen tiplerinin çoğunun daha önce polinosisin ana nedenleri olarak rapor edilmeleri dikkat çekicidir.

Introduction

Pollen is the male gametophyte that plays an important role in pollination of flowering plants. The movements of pollens from one flower to the others can take place through different ways but wind and insects are the two vectors with the greatest share in pollination. Atmospheric occurences of pollens of wind pollinated plants are considered to be very important in terms of human health. Pollens found in the atmosphere may cause allergic symptoms in susceptible individuals like mucous membrane irritation, chronic bronchitis, allergic rhinitis and asthma, extrinsic allergic alveolitis (hypersensitivity pneumonitis), inhalation fever, humidifier fever or organic dust toxic syndrome, and immunological response impairment (Lacey & Dutkiewicz 1994). It has been reported that the ratio of individuals complaining from pollinosis in Europe reached up to 40% (D'Amato *et al.* 2007). The changing meteorological conditions and climate along with the increasing air pollution in urbanized areas increase the allergenicity of pollen grains in the atmosphere. For this reason, pollen calendars have been prepared in many countries (Giner *et al.* 2002, Peternel *et al.* 2003, Ianovici *et al.* 2013, Ribeiro & Abreu 2014, Puljak *et al.* 2016) and in Turkey (Bicakci *et al.* 2002, Guvensen & Ozturk 2003, Altunoglu *et al.* 2008, Tosunoglu *et al.* 2009, Çeter *et al.* 2011, Tosunoglu & Bicakci 2015, Uguz *et al.* 2018).

This study was performed *i*) to determine airborne pollen types and their densities in the atmosphere of

Dursunbey in Balıkesir province in Turkey, *ii*) to show seasonal variations of pollen types and *iii*) to prepare a pollen calendar for the sampling area.

Materials and Methods

The study area

Dursunbey is located at 39° 34.8' N, 28° 37.8' E in northwest of Turkey at an altitude of 639 m above sea level. It covers an area in the eastern part of Balıkesir and geographically occupy a place in Marmara region of the country. The hilly characteristic of the study area is notable and most parts of the area is covered with *Pinus nigra* Arn. forests, making Dursunbey a famous region with its timber and a well-known exporter of it. The region has a Mediterranean climate type and the floristic structure shows transitional features between Euro-Siberian and Mediterranean phytogeographic regions. The major vegetation in the study area and its surroundings consists of *Pinus nigra* Arn. subsp. *pallasiana* (Lamb.) Holmboe, *Abies nordmanniana* (Stev.) subsp. *bornmuelleriana* (Mattf.) Coode & Cullen, *Cupressus sempervirens* L., *Juniperus communis* L. subsp. *saxatilis* Pall., *Juniperus oxycedrus* L. subsp. *oxycedrus*, *Alnus glutinosa* (L.) Gaertner subsp. *antitaurica* Yalt., *Carpinus betulus* L., *Carpinus orientalis* Miller, *Fagus orientalis* Lipsky., *Fagus sylvatica* L., *Quercus pubescens* Willd., *Quercus cerris* L. var. *cerris* L., *Corylus avellana* L., *Populus tremula* L., *Fraxinus excelsior* L., *Fraxinus ornus* L., *Acer campestre* L., *Ulmus glabra* (Hudson), *Cistus laurifolius* L., *Arbutus unedo* L., and *Robinia pseudoacacia* L. (Dirmenci 2006, Açar & Satıl 2014). Afforestation areas of *Cedrus libani* A. Rich. can also be seen. The southern parts are are dominated by Mediterranean maquis elements in addition to the natural vegetation of *Acer* sp., *Betula* sp., *Cupressus arizonica* Green, *Elaeagnus angustifolia* L., *Juglans regia* L., *Malus domestica* Borkh., *Morus* sp., *Olea europaea* L., *Platanus orientalis* L., *Populus* sp., and *Prunus* species as members of parks, gardens, and streets.

Palynological study

A Durham sampler was used as the gravimetric sampler which was operated from January to December 2012. The sampler was placed on the roof of a building at a height of 9 m above ground level. The slides of the sampler were covered with glycerine jelly mixed with basic fuchsin (Charpin & Surinyach 1974) before exposure and were changed weekly with new ones. Weekly slides were examined by light microscopy (Olympus BX51 trinocular light microscope) and the raw data was converted to pollen number in cm^2. For pollen assignments, Uludağ University Palynology Laboratory reference collection was used.

Results

A total of 6265 pollen grains from 42 taxa were recorded in the atmosphere of Dursunbey annually. Most of the pollen grains (5399 grains of 24 taxa, 86.17%) were found to be arboreal, while 824 pollen grains of 18 taxa (13.16%) were non-arboreal. A small portion of the pollens (42 grains, 0.67%) were unidentified (Table 1).

Pollen grains were recorded every month except December (Fig. 1, Table 2). During the first six months of the sampling, arboreal pollen grains dominated the atmosphere, and in July, August, September and October non-arboreal grains were dominant. Arboreal grains were not sampled in November and non-arboreal grains were not sampled during the first three months (Fig. 1, Table 2). The most common arboreal pollen producers were found as *Pinus* (48.23%), Cupressaceae/Taxaceae (16.74%), *Quercus* (5.31%), *Acer* (4.07%), *Platanus* (3.10%), *Juglans* (2.26%), *Abies* (1.75%), *Olea* (1.16%) constituting 82.62% of the total pollen number (Fig. 3, Table 1). The most frequently recorded non-arboreal pollen grains belonged to Poaceae (8.32%), *Plantago* (1.25%) and Amaranthaceae (1.22%), which constituted 10.73% of the total pollen number (Fig. 2, Table 1).

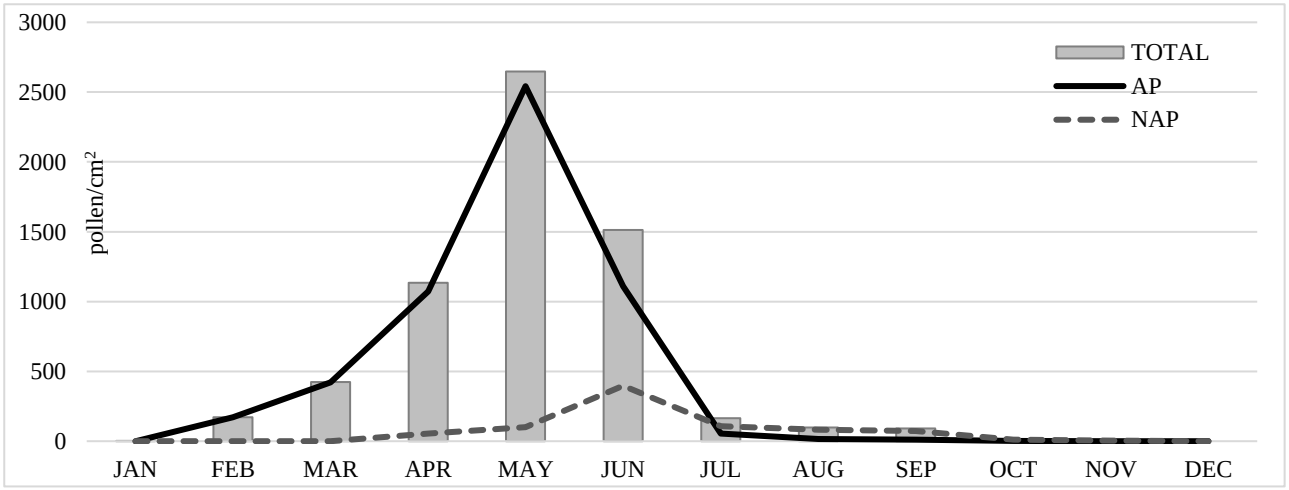

Fig. 1. Monthly distribution of the pollen grains sampled based on their numbers per cm^2. AP; arboreal pollen grains, NAP; non-arboreal pollen grains.

Table 1. The annual pollen numbers and percentages of arboreal plants (AP) and non-arboreal plants (NAP) sampled in the atmosphere of Dursunbey.

ARBOREAL PLANTS	Annual number	%
Pinus	3022	48.23
Cupressaceae/Taxaceae	1049	16.74
Quercus	332	5.31
Acer	255	4.07
Platanus	194	3.10
Juglans	142	2.26
Abies	110	1.75
Olea europaea	73	1.16
Fagus	42	0.67
Fraxinus	37	0.58
Alnus	31	0.49
Populus	31	0.49
Betula	20	0.31
Ericaceae	14	0.22
Pistacia	14	0.22
Carpinus	6	0.10
Rosaceae	5	0.09
Tilia	5	0.08
Ulmus	5	0.07
Morus	4	0.06
Salix	4	0.06
Cedrus	3	0.05
Corylus	2	0.03
Acacia	1	0.02
Total (AP)	**5399**	**86.17**
NON-ARBOREAL PLANTS	**Annual number**	**%**
Poaceae	521	8.32
Plantago	78	1.25
Amaranthaceae	76	1.22
Xanthium	34	0.54
Boraginaceae	19	0.30
Apiaceae	17	0.28
Asteraceae	13	0.21
Lamiaceae	11	0.17
Fabaceae	10	0.16
Urticaceae	10	0.15
Taraxacum	8	0.13
Brassicaceae	7	0.10
Artemisia	6	0.09
Campanulaceae	5	0.08
Juncaceae	4	0.07
Cyperaceae	3	0.04
Papaveraceae	2	0.03
Caryophyllaceae	1	0.02
Total (NAP)	**824**	**13.16**
Unidentified	42	0.67
TOTAL	**6265**	**100.00**

The most common arboreal pollen producers were found as *Pinus* (48.23%), Cupressaceae/Taxaceae (16.74%), *Quercus* (5.31%), *Acer* (4.07%), *Platanus* (3.10%), *Juglans* (2.26%), *Abies* (1.75%), *Olea* (1.16%) constituting 82.62% of the total pollen number (Fig. 3, Table 1). The most frequently recorded non-arboreal pollen grains belonged to Poaceae (8.32%), *Plantago* (1.25%) and Amaranthaceae (1.22%), which constituted 10.73% of the total pollen number (Fig. 2, Table 1).

The earliest airborne pollen grain recorded with 1 pollen (0.01% of the total pollen grains) was in January and belonged to *Alnus* (Table 2). In February, 172 pollen grains, constituting 2.75% of the annual count, were recorded. The dominating pollen grains (1.88%) in February belonged to Cupressaceae/Taxaceae (Table 2). The number of airborne pollen grains and the number of pollen types these grains belonged to increased in March and April with 424 (6.77%) and 1134 pollens (18.09%), respectively. Dominating taxa were Cupressaceae/Taxaceae (5.44%) in March and *Pinus* (6.55%), Cupressaceae/Taxaceae (6.47), *Platanus* (1.61%), and *Quercus* (1.22%) in April (Table 2).

The highest pollen level during the sampling period was recorded in May with 2648 pollen grains (42.26%) originating from *Pinus* (26.02%), *Quercus* (3.64%), *Acer* (3.61%), Cupressaceae/Taxaceae (2.35%), *Juglans* (1.93%), *Platanus* (1.49%), and Poaceae (1.34%) (Fig. 1, Table 2). The highest pollen load of the air was observed in the 3rd week of May (20th week) with 894 pollen grains. In June, during which 1514 pollen grains were recorded, the dominating pollen grains belonged to *Pinus* (14.54%), Poaceae (4.70%), and *Olea* (1.02%) making 24.16% of the total pollen load. The numbers of pollen grains started to decrease by July and the decrease continued in August and September. In July, 165 pollen grains were recorded (2.63%) followed by 99 pollen grains (1.58%) in August and 90 pollen grains in September (Table 2). The pollen load was very low in October (0.23%) and November (0.07%) and no pollen grains were recorded in December (Fig. 1, Table 2).

Pollen types that comprised more than 1% of the annual total pollen number were considered to be dominant. Weekly variations of these dominated taxa are shown in Fig. 3 and pollen calendar that shows pollination seasons of all identified taxa are shown in Fig. 4.

The pollen season of *Pinus* started by the beginning of March (9th week) and lasted in the 4th week of September (38th week). The highest level of *Pinus* pollens was recorded in the 4th week of April (17th week) with 558 pollen grains (Figs. 3-4). Cupressaceae/Taxaceae pollens started to appear in the 1st week of February (5th week), the peak value was recorded in the 4th week of April with 267 pollen grains and disappearance took place in the 3rd week of October (42nd week) (Figs. 3-4). The relatively short pollen season of *Quercus* started in the 1st week of April (14th week) and lasted in the 3rd week of June. The highest levels of oak pollen grains were recorded in the 2nd week of May (19th week) with 112 grains (Figs. 3-4). Pollen grains of *Acer* were found as a predominating pollen type with an annual percentage of 4.07 (Table 1).

Table 2. Monthly percentages of airborne pollen grains of arboreal plants (AP) and non-arboreal plants (NAP)in the atmosphere of Dursunbey.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ARBOREAL PLANTS	*Abies*	-	-	-	0.07	0.58	0.97	0.10	0.04	-	-	-	-
	Acacia	-	-	-	0.02	-	-	-	-	-	-	-	-
	Acer	-	0.04	0.13	0.26	3.61	0.03	-	-	-	-	-	-
	Alnus	0.01	0.45	0.04	-	-	-	-	-	-	-	-	-
	Betula	-	0.22	0.09	-	-	-	-	-	-	-	-	-
	Carpinus	-	-	0.06	0.03	-	-	-	-	-	-	-	-
	Cedrus	-	-	-	-	-	-	-	-	0.05	-	-	-
	Corylus	-	0.01	0.02	-	-	-	-	-	-	-	-	-
	Cup./Taxaceae	-	1.88	5.44	6.47	2.35	0.46	0.07	0.02	0.03	0.02	-	-
	Ericaceae	-	-	-	0.05	0.10	0.05	-	-	0.02	-	-	-
	Fagus	-	-	-	0.43	0.24	-	-	-	-	-	-	-
	Fraxinus	-	0.04	0.21	0.02	0.31	-	-	-	-	-	-	-
	Juglans	-	-	-	0.27	1.93	0.05	-	-	-	-	-	-
	Morus	-	-	-	0.05	0.02	-	-	-	-	-	-	-
	Olea europaea	-	-	-	-	0.14	1.02	-	-	-	-	-	-
	Pinus	-	-	0.20	6.55	26.02	14.54	0.67	0.18	0.08	-	-	-
	Pistacia	-	-	0.02	0.06	0.10	0.04	-	-	-	-	-	-
	Platanus	-	-	-	1.61	1.49	-	-	-	-	-	-	-
	Populus	-	0.08	0.41	-	-	-	-	-	-	-	-	-
	Quercus	-	-	-	1.22	3.64	0.44	-	-	-	-	-	-
	Rosaceae	-	-	-	-	-	0.07	0.02	-	-	-	-	-
	Salix	-	-	0.05	0.01	-	-	-	-	-	-	-	-
	Tilia	-	-	-	-	0.05	0.03	-	-	-	-	-	-
	Ulmus	-	0.02	0.06	-	-	-	-	-	-	-	-	-
	Total (AP)	**0.01**	**2.73**	**6.72**	**17.13**	**40.58**	**17.71**	**0.86**	**0.24**	**0.17**	**0.02**	**-**	**-**
NON-ARBOREAL PLANTS	*Artemisia*	-	-	-	-	-	-	-	0.05	0.04	-	-	-
	Boraginaceae	-	-	-	-	-	0.23	0.05	0.02	-	-	-	-
	Campanulaceae	-	-	-	0.05	0.02	0.01	-	-	-	-	-	-
	Caryophyllaceae	-	-	-	0.02	-	-	-	-	-	-	-	-
	Amaranthaceae	-	-	-	-	-	0.13	0.23	0.33	0.42	0.07	0.03	-
	Asteraceae	-	-	-	-	0.04	0.06	0.04	0.03	0.03	0.02		
	Berassicaceae	-	-	-	0.02	0.02	0.03	0.02	0.02	-	-	-	-
	Cyperaceae	-	-	-	-	-	0.02	0.02	-	-	-	-	-
	Poaceae	-	-	-	0.64	1.34	4.70	0.77	0.39	0.36	0.08	0.04	-
	Juncaceae	-	-	-	0.02	0.03	0.02	-	-	-	-	-	-
	Lamiaceae	-	-	-	0.02	0.01	0.02	0.10	0.02	-	-	-	-
	Fabaceae	-	-	-	0.03	0.02	-	0.05	0.03	0.03	-	-	-
	Papaveraceae	-	-	-	-	-	0.03	-	-	-	-	-	-
	Plantago	-	-	-	0.06	0.08	0.79	0.24	0.08	-	-	-	-
	Taraxacum	-	-	-	0.02	-	0.02	0.04	0.02	0.05	-	-	-
	Apiaceae	-	-	-	0.02	-	0.14	0.10	0.02	-	-	-	-
	Urticaceae	-	-	-	-	-	0.10	0.05	-	-	-	-	-
	Xanthium	-	-	-	-	-	-	-	0.31	0.23	-	-	-
	Total (NAP)	**-**	**-**	**-**	**0.87**	**1.56**	**6.31**	**1.71**	**1.31**	**1.16**	**0.17**	**0.07**	**-**
	Unidentified	-	0.02	0.05	0.10	0.13	0.14	0.06	0.03	0.10	0.05	-	-
	TOTAL	**0.01**	**2.75**	**6.77**	**18.09**	**42.26**	**24.16**	**2.63**	**1.58**	**1.44**	**0.23**	**0.07**	**-**

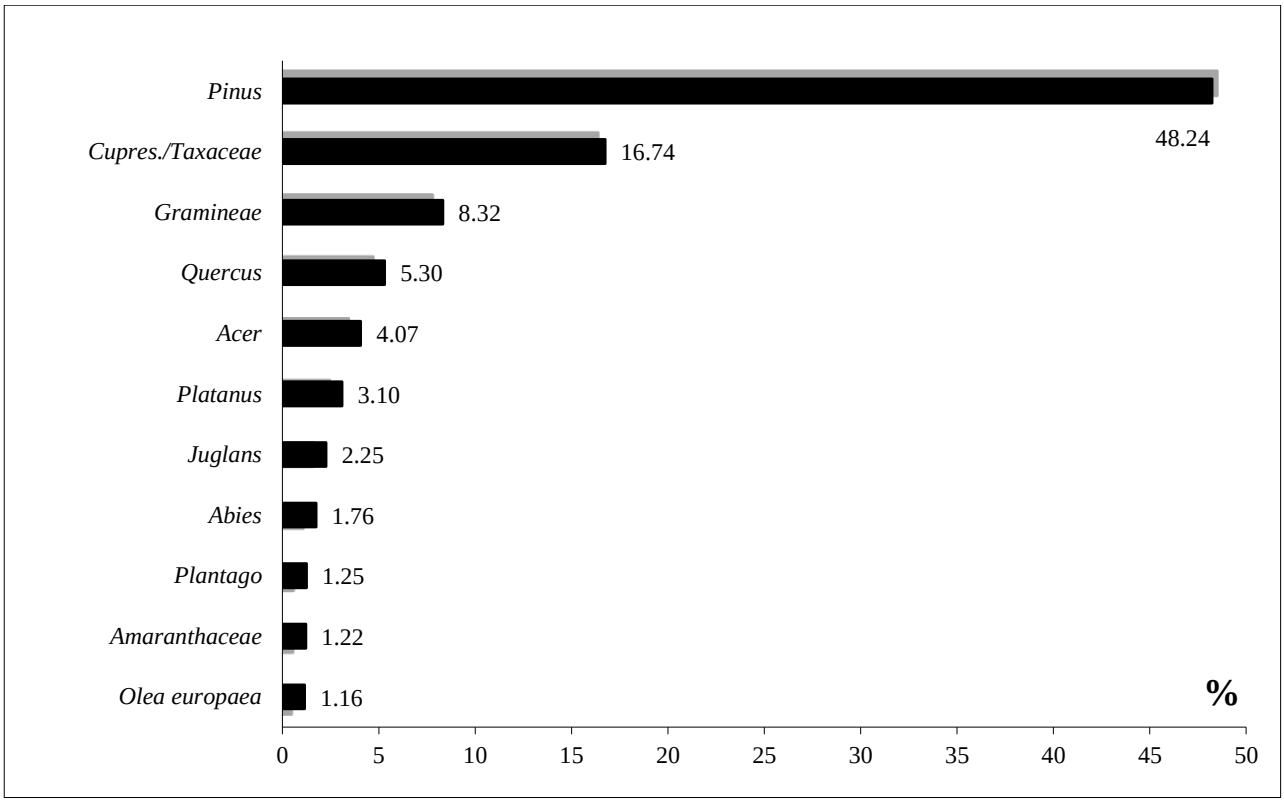

Fig. 2. The annual percentages of main pollen types determined in the atmosphere of Dursunbey.

The pollen season of *Acer* started in the 2nd week of February (6th week) and lasted in the 1st week of June (22nd week). The highest number of *Acer* pollen grains (117 pollen grains) were recorded in the 3rd week of May (20th week) (Figs. 3-4). The pollen season of *Platanus* was very short and started in the 2nd week of April and lasted in the 4th week of May (21st week). The highest pollen number of this genus (73 pollen grains) was recorded in the 4th week of April (Figs. 43-4). The pollen season of *Juglans* began in the 3rd week of April (16th week) and lasted by the beginning of June. The highest levels of *Juglans* pollens were observed in the 2nd week of May with 66 pollen grains (Figs. 3-4).

Juglans appeared to be one of the main pollen producers with an annual value of 2.26%. The pollen grains of *Abies* were sampled from the 3rd week of April until the 3rd week of August (33rd week). Maximum pollen load of *Abies* was recorded in the last week of June (26th week) with 32 pollen grains (Figs. 3-4). The last dominating pollen type was of *Olea europaea* and showed a very short pollen season, which started in the 4th week of May (2st week) and lasted in the last week of June. The highest level of *Olea europaea* pollen grains (39 grains) was recorded in the 1st week of June (Figs. 3-4).

Poaceae was the most common herbaceous plant whose pollen grains started to be seen from the 2nd week of April (15th week) to the end of November (47th week) with its highest value in the 3rd week of June (24th week) with 92 pollen grains (Figs. 3-4). The pollen season of *Plantago* started in the 2nd week of April and lasted at the end of August. The highest number of *Plantago* pollen grains was recorded in the 3rd week of June with 16 pollen grains (Figs. 3-4). The pollen season of the family Amaranthaceae was long and started by the beginning of June and lasted in the 1st week of November (44th week). The highest number of pollen grains (10 grains) was recorded in the 1st week of September (35th week) (Figs. 3-4).

Discussion

Airborne pollen grains of arboreal plants were found to be predominant in the atmosphere of Dursunbey with a ratio of 86.17% most probably as a result of the geographical location, climate and vegetation of the study area. The same dominancy for arboreal pollen types have previously been reported in Balıkesir (70.92%) (Bicakci and Akyalcin 2000), Gemlik (82.39%) (Saatcioglu *et al.* 2011), Konya (61.29%) (Kizilpinar *et al.* 2012) and Büyükorhan (87.46%) (Tosunoglu *et al.* 2015b) in Turkey and in Zagreb (69.14%) (Peternel *et al.* 2003) in Crotia.

The pollen grains of pine was the most frequent pollen type during the investigation period due to widespread pine forests present at higher altitudes of the study area and its surroundings. Pine pollen has previously been recorded as a predominated pollen type with high percentages also in İzmir (57.30%) (Guvensen *et al.* 2003), Sivrihisar (48.13%) (Potoglu Erkara 2008), Köyceğiz (48.01%) (Tosunoglu *et al.* 2009) and Sakarya (14.10%) (Bicakci 2006) in Turkey. Pine pollens were commonly identified at family level in many

aerobiological studies and were thought as a group of vesiculate type pollen grains because of their similar and low allergenic potential. On the contrary, there are different hypotheses about the remarkable allergenicity in high levels of Pinaceae pollen in the air (Harris & German 1995, Marcos *et al.* 2001). Pollen grains of *Abies*, another conifer genus, were also found to dominate the total pollen load of atmosphere of our study area. Similarly, *Abies* pollen grains have previously been to predominate in Savaştepe (Bilisik *et al.* 2008b), Bilecik (Türe & Böcük 2009) and Büyükorhan (Tosunoglu *et al.* 2015b) in Turkey.

Cupressaceae/Taxaceae type pollens were shown to be an important aeroallergen and a major cause of winter and early spring pollinosis around the Mediterranean basin (Charpin 2005, D'Amato *et al.* 2007). Cupressaceae/Taxaceae pollen was the second dominating pollen type in our study and previously was reported as the main pollen type in Balıkesir (15.73%) (Bicakci & Akyalcin 2000), Kuşadası (30.04%) (Tosunoğlu *et al.* 2013), Büyükorhan (20.69%) (Tosunoglu *et al.* 2015b) and Antalya (38.33%) (Tosunoglu *et al.* 2015a) in Turkey and in Cax do Sul (7.7%) (Vergamini *et al.* 2006) in Brazil.

Quercus, one of the main allergenic pollen types (Spieksma 1990, D'Amato *et al.* 1991) was found as a predominated pollen type with the annual percentage of 5.31% in the atmosphere of our study area (Table 1). *Quercus* has previously been reported as the main pollen type from many regions in Turkey including Çanakkale (9.28%) (Guvensen *et al.* 2005), Karabük (5.89%) (Kaplan and Özdoğan 2015), Fethiye (2.34%) (Bilisik *et al.* 2008a), Antalya (4.58%) (Tosunoglu *et al.* 2015a) and Bodrum (15.95%) (Tosunoglu & Bicakci 2015). Pollen grains of *Platanus* are another important allergen (Subiza *et al.* 1994, Varela *et al.* 1997) and were also reported as a predominant pollen type from Kuşadası (Tosunoglu *et al.* 2013), Denizli (Guvensen *et al.* 2013) and Antalya in Turkey (Tosunoglu *et al.* 2015a). . *Olea europaea* has been reported as a predominated pollen type and the main cause of pollinosis around the Mediterranean basin (D'Amato & Liccardi 1994, Liccardi *et al.* 1996, Diaz de la Guardia *et al.* 2003, Gioulekas *et al.* 2004). On the other hand, *Acer* and *Juglans* pollen were not reported as highly allergenic pollen types in previous studies (Esch *et al.* 2001, D'Amato *et al.* 2007).

Poaceae, Amaranthaceae and *Plantago* pollens were the most frequent herbaceous pollen types in Dursunbey atmosphere. Poaceae pollens have previously been reported as an important aeroallergen (Bousquet *et al.* 1984, D'Amato & Spieksma 1992, D'Amato *et al.* 2007, Mandal *et al.* 2008). Pollens of members of this family are frequently seen in high levels during summer periods according to the variable vegetation period in many studies and were reported as a predominant pollen type in Kayseri(20.44%) (Ince *et al.* 2004), Yalova (10.01%) (Altunoglu *et al.* 2008), Gemlik (10.67%) (Saatcioglu *et al.* 2011) and Van (20.94%) (Bicakci *et al.* 2017) in Turkey and in Calcutta (12.98%) (Mandal *et al.* 2008) in India. *Plantago* pollens were mostly reported as an important cause of pollinosis (Bicakci *et al.* 2011) and were found to predominate in the atmosphere of our study region, as in the case reported in previous studies (Guvensen *et al.* 2005, Altunoglu *et al.* 2008, Tosunoglu & Bicakci 2015). Another important aeroallergen is Amaranthaceae pollens (Fang *et al.* 2001) which were found to dominate in the atmosphere of our study area with a percentage of 1.22% (Table 1).

The results of former studies in various countries showed that *Platanus*, Poaceae, *Acer*, *Cupressus*, Chenopodiaceae, Urticaceae, *Morus*, *Plantago* and Oleaceae pollens were the dominant pollen types in Santiago, Chile (Villegas & Nolla 2001), *Betula*, *Corylus*, *Ambrosia*, Urticaceae pollens in Zagreb, Croatia (Peternel *et al.* 2003), Cupressaceae, Pinaceae, Urticaceae, Anacardiaceae, Oleaceae and Polygonaceae pollens in Cagliari, Italy (Ballero & Maxia 2003), Taxus/Cupressaceae, *Quercus*, Poaceae, *Pinus*, *Betula*, Urticaceae and *Fraxinus* pollens in Neuchâtel, Switzerland (Clot 2003), Cupressaceae, Poaceae, Hamamelidaceae, Pinaceae, Urticaceae, *Quercus*, *Acer*, Myrtaceae, Caryophyllaceae, Oleaceae, Betulaceae and *Plantago* pollens in Porto region, Portugal (Abreu *et al* 2003), *Betula*, Pinaceae, *Alnus*, Poaceae and *Urtica* pollens in Lublin, Poland (Weryszko-Chmielewska and Piotrowska, 2004), Cupressaceae, *Quercus*, Urticaceae, Oleaceae, Pinaceae, Poaceae, Platanaceae, *Corylus*, Chenopodiaceae and *Populus* pollens in Thessaloniki, Greece (Gioulekas *et al.* 2004), *Pinus*, Cupressaceae, Poaceae, *Platanus*, *Quercus*, *Artemisia*, Amaranthaceae and Urticaceae pollens in Isparta, Turkey (Bicakci *et al.* 2000), *Pinus*, Cupressaceae/Taxaceae, Gramineae, *Platanus*, *Quercus*, *Olea*, *Salix*, Urticaceae, Moraceae, *Plantago*, Chenopodiaceae/Amaranthaceae, *Ailanthus*, *Juglans*, *Carpinus* and Rosaceae pollens in Balıkesir (Bicakci & Akyalcin 2000); *Pinus*, *Quercus*, Cupressaceae/Taxaceae, *Salix*, *Platanus*, *Populus*, *Carpinus*, *Fagus*, Moraceae, *Corylus*, *Fraxinus*, Gramineae, Chenopodiaceae/ Amaranthaceae, *Xanthium* and Urticaceae pollens in Sakarya (Bicakci 2006) and *Olea europaea*, Cupressaceae/ Taxaceae, *Pinus*, *Platanus*, Poaceae, and *Morus* pollens in Kuşadası, Turkey (Tosunoğlu *et al.* 2013).

In conclusion, the annual sampling of the airborne pollen grains in Dursunbey atmosphere showed presence pollens of 24 arboreal and 18 non-arboreal plants. A total number of 6265 pollen grains per cm^2 were counted during the sampling period and the main pollen producers were recorded as *Pinus*, Cupressaceae/Taxaceae, Poaceae, *Quercus*, *Acer*, *Platanus*, *Juglans*, *Abies*, *Plantago*, Amaranthaceae, and *Olea* in Dursunbey atmosphere. Most of the predominated pollen types have previously been reported as important allergenic pollen types. We hope the calendar designed by us will be helpful for medical treatment of patients complaining from pollen allergy in Dursunbey and its surroundings.

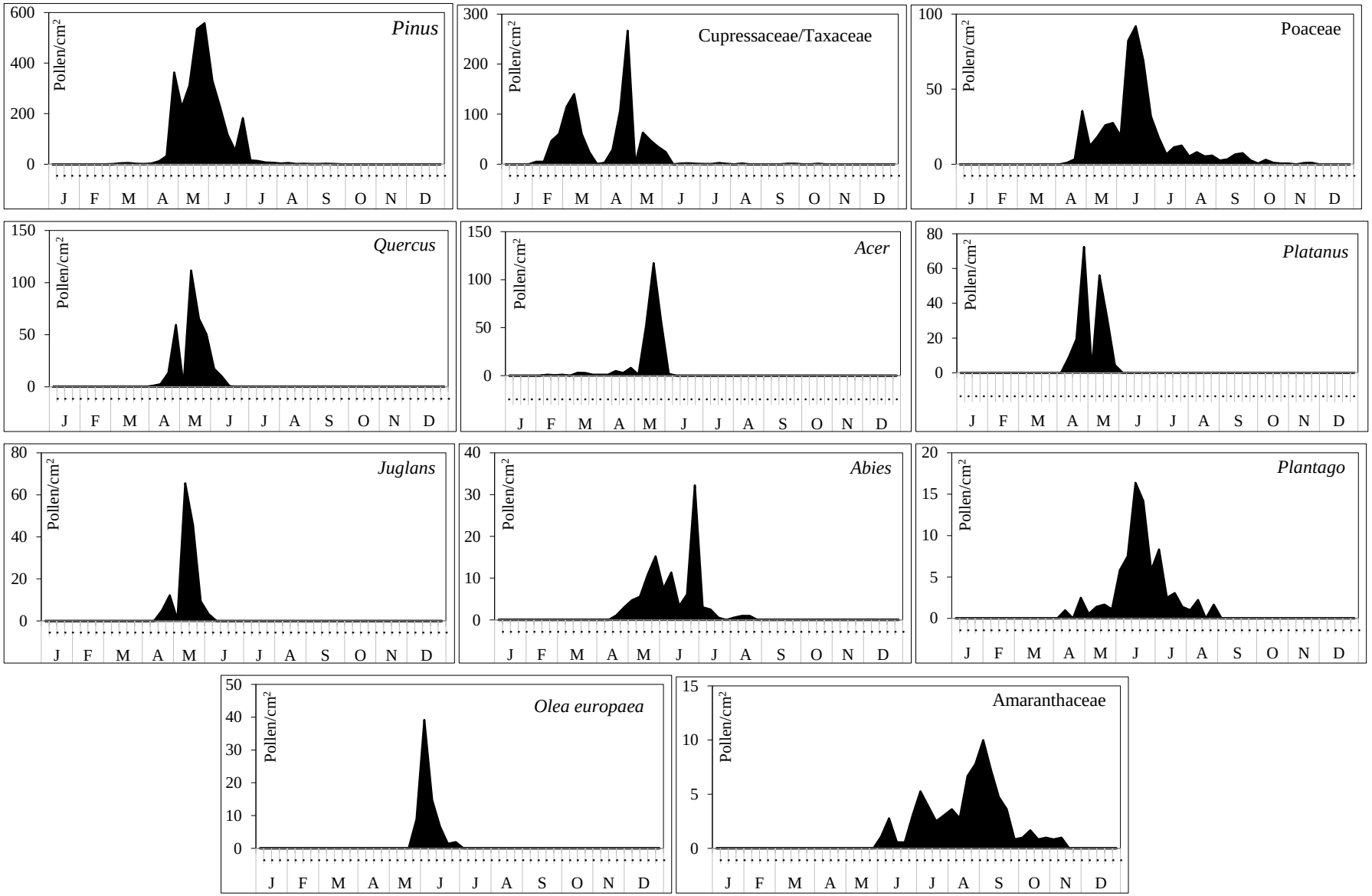

Fig. 3. Main pollen producers and their weekly variations in the atmosphere of Dursunbey. The letters in the *X* axis correspond to the sampling months.

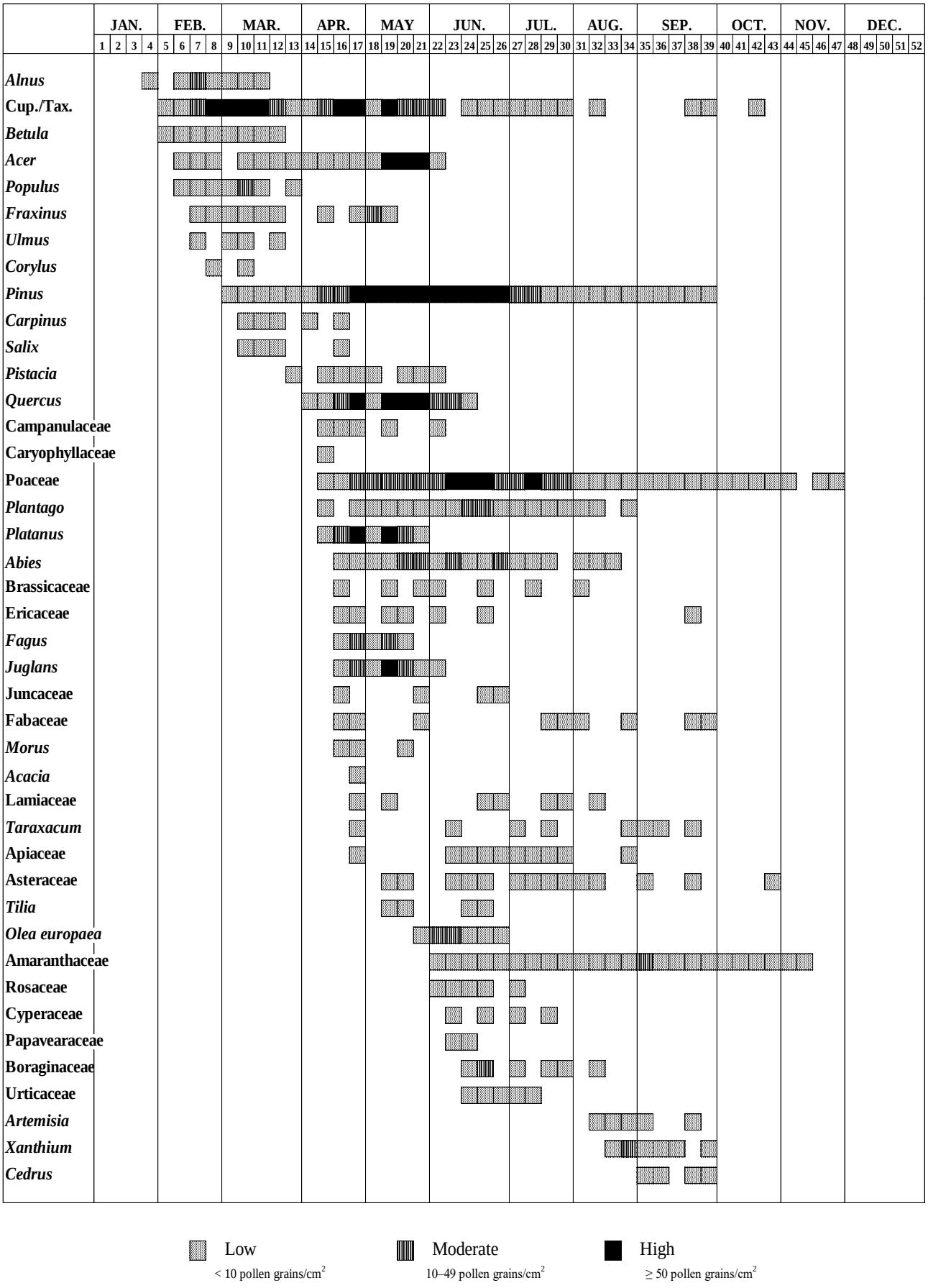

Fig. 4. Annual airborne pollen calendar of Dursunbey.

References

1. Abreu, I., Ribeiro, H. & Cunha, M. 2003. An Aerobiological study of the Porto region (Portugal). *Aerobiologia*, 19: 235-241.
2. Açar, M. & Satıl, F. 2014. Flora of Akdağ (Balıkesir, Dursunbey/Turkey). *Biological Diversity and Conservation*, 7(2): 38-56.
3. Altunoglu, M.K., Bicakci, A., Celenk, S., Canitez, Y., Malyer, H. & Sapan N. 2008. Airborne pollen grains in Yalova, Turkey, 2004. *Biologia*, 63(5): 658-663.
4. Ballero, M. & Maxia, A. 2003. Pollen spectrum variations in the atmosphere of Cagliari, Italy. *Aerobiologia*, 19: 251-259.
5. Bicakci, A. 2006. Analysis of airborne pollen fall in Sakarya, Turkey. *Biologia*, 61(4): 457-461.
6. Bicakci, A. & Akyalcin, H. 2000. Analysis of airborne pollen fall in Balıkesir, Turkey, 1996-1997. *Annals of Agricultural and Environmental Medicine*, 7: 5-10.
7. Bicakci, A., Akkaya, A., Malyer, H., Unlu, M. & Sapan, N. 2000. Pollen calendar of Isparta, Turkey. *Israel Journal of Plant Sciences*, 48: 67-70.
8. Bicakci, A., Ergun, S., Tatlidil, S., Malyer, H., Ozyurt, S., Akaya, A. & Sapan, N. 2002. Airborne pollen grains of Afyon, Turkey. *Acta Botanica Sinica*, 44: 1371-1375.
9. Bicakci, A., Altunoglu, M.K., Tosunoglu, A., Akkaya, A., Malyer, H. & Sapan, N. 2011. Allergenic *Plantago* (plantain) pollen concentrations in Turkey. *Asthma Allergy Immunology*, 9: 144-153.
10. Bicakci, A., Tosunoglu, A., Altunoglu, M.K., Saatcioglu, G., Keser, A.M. & Ozgokce, F. 2017. An aeropalynological survey in the city of Van, a high altitudinal region, East Anatolia-Turkey. *Aerobiologia*, 33: 93-108.
11. Bilisik A., Bicakci A., Malyer H. & Sapan N. 2008a. Analysis of Airborne pollen concentrations in Fethiye-Mugla, Turkey. *Fresenius Environmental Bulletin*, 17(6): 640-646.
12. Bilisik, A., Akyalcin, H. & Bicakci, A. 2008b. Airborne pollen grains in Savaştepe (Balikesir). *Ekoloji*, 67: 8-14.
13. Bousquet, J., Cour, P., Guerin, B. & Michel. F.B. 1984. Allergy in the Mediterranean area. I. Pollen counts and pollinosis of Montpellier. *Clinical Allergy*, 14: 249-258.
14. Ceter, T., Pinar, N.M., Guney, K., Yildiz, A., Aşcı, B. & Smith, M. 2011. A 2-year aeropalynological survey of allergenic pollen in the atmosphere of Kastamonu, Turkey. *Aerobiologia*, 28(3): 355-366.
15. Charpin, J. & Surinyach, R. 1974. *Atlas of European allergenic pollen.* Sandoz Editions, Paris. 9-18.
16. Charpin, D. 2005. Allergy to cypress pollen. *Allergy*, 60: 293-301.
17. Clot, B. 2003. Trends in airborne pollen: An overview of 21 years of data in Neuchâtel (Switzerland). *Aerobiologia*, 19: 227-234.
18. D'Amato, G., Spieksma, F.Th.M. & Bonini, S. 1991. *Allergenic pollen and pollinosis in Europe*. Blackwell Scientific Publications, Oxford, 226 pp.
19. D'Amato, G, & Spieksma, F.Th.M. 1992. European allergenic pollen types. *Aerobiologia*, 8: 447-450.
20. D'Amato, G. & Liccardi, G. 1994. Pollen related allergy in the European Mediterranean area. *Clinical and Experimental Allergy*, 24: 210-219.
21. D'Amato, G., Cecchi, L., Bonini, S., Nunes, C., Annesi-Maesano, I., Behrendt, H., Liccardi, G., Popov, T. & van Cauwenberge, P. 2007. Allergenic pollen and pollen allergy in Europe. *Allergy*, 62: 976-990.
22. Diaz de la Guardia, C., Alba, F., Trigo, M.D.M., Galán, C., Ruíz, L., & Sabariego, S. 2003. Aerobiological analysis of *Olea europaea* L. pollen in different localities of southern Spain. *Grana*, 42(4): 234-243.
23. Dirmenci, T. 2006. Gölcük (Dursunbey-Balıkesir) florası üzerine bir çalışma. *Ot Sistematik Botanik Dergisi*, 13(1): 97-124.
24. Esch, R.E., Hartsell, C.J., Crenshaw, R. & Jacobson R.S. 2001. Common allergenic pollens, fungi, animals and arthropods. *Clinical Reviews in Allergy and Immunology*, 21(2-3): 261-292.
25. Fang, R., Xie, S. & Wei, F. 2001. Pollen survey and clinical research in Yunnan, China. *Aerobiologia*, 17: 165-169.
26. Giner, M.M., Garcīa, J.S.C. & Camacho, C.N. 2002. Seasonal fluctuations of the airborne pollen spectrum in Murcia (SE Spain). *Aerobiologia*, 18: 141-151.
27. Gioulekas, D., Balafoutis, C., Damialis, A., Papakosta, D., Gioulekas, G. & Patakas, D. 2004. Fifteen years' record of airborne allergenic pollen and meteorological parameters in Thessaloniki, Greece. *International Journal of Biometeorology*, 48: 128-136.
28. Guvensen, A. & Ozturk, M. 2003. Airborne Pollen Calendar of Izmir-Turkey. Annals of *Agricultural and Environmental Medicine*, 10: 37-44.
29. Guvensen, A., Uysal, I., Celik, A. & Ozturk, M. 2005 Analysis of airborne pollen fall in Çanakkale, Turkey. *Pakistan Journal of Botany*, 37: 507-518.
30. Guvensen, A., Celik, A., Topuz, B., & Ozturk, M. 2013. Analysis of airborne pollen grains in Denizli. *Turkish Journal of Botany*, 37: 74-84.
31. Harris, R.M. & German, D.F. 1985. The incidence of pine pollen reactivity in an allergic atopic population. *Annals of Allergy*, 55: 678-679.
32. Ianovici, N., Panaitescu, C.B. & Brudiu, I. 2013. Analysis of airborne pollen spectrum for 2009 in Timişoara, Romania. *Aerobiologia*, 29: 95-111.
33. Ince, A., Kart, L., Demir, R. & Ozyurt, M.S. 2004. Allergenic pollen in the atmosphere of Kayseri, Turkey. *Asian Pacific Journal of Allergy and Immunology*, 22: 123-132.
34. Kaplan, A. & Özdoğan, Y. 2015. Seasonal variations of airborne pollen grains in Karabük, Turkey. *Karaelmas Science and Engineering Journal*, 5(2): 89-100.
35. Kizilpinar, I., Dogan, C., Artac, H., Reisli, I. & Pekcan, S. 2012. Pollen grains in the atmosphere of Konya (Turkey)

and their relationship with meteorological factors, in 2008. *Turkish Journal of Botany*, 36: 344-357.

36. Lacey, J. & Dutkiewicz, J. 1994. Bioaerosols and occupational lung disease. *Journal of Aerosol Science*, 25: 1371-1404.

37. Liccardi, G., D'Amato, M. & D'Amato, G. 1996. Oleaceae pollinosis: A review. *International Archives of Allergy and Immunology*, 111: 210-217.

38. Mandal, J., Chakraborty, P., Roy, I., Chatterjee, S. & Gupta-Bhattacharya, S. 2008. Prevalence of allergenic pollen grains in the aerosol of the city of Calcutta, India: a two year study. *Aerobiologia*, 24: 151-164.

39. Marcos, C., Rodriguez, F. J., Luna, I., Jato, V. & González, R. 2001. Pinus pollen aerobiology and clinical sensitization in northwest Spain. *Annals of Allergy, Asthma & Immunology*, 87(1): 39-42.

40. Peternel, R., Čulig, J., Mitić, B., Vukušić, I. & Šostar. Z. 2003. Analysis of airborne pollen concentrations in Zagreb, Croatia, 2002. *Annals of Agricultural and Environmental Medicine*, 10: 107-112.

41. Potoglu Erkara, I. 2008. Concentrations of airborne pollen grains in Sivrihisar (Eskisehir), Turkey. *Environmental and Monitoring Assessment*, 138: 81-91.

42. Puljak, T., Mamić M., Mitić, B., Hrga, I. & Hruševar, D. 2016. First aerobiological study in Mediterranean part of Croatia (Dalmatia): pollen spectrum and seasonal dynamics in the air of Split. *Aerobiologia*, 32: 709-723.

43. Ribeiro, H. & Abreu, I. 2014. A 10-year survey of allergenic airborne pollen in the city of Porto (Portugal). *Aerobiologia*, 30: 333-344.

44. Saatçıoğlu, G., Tosunoğlu, A., Malyer, H. & Bıçakçı, A. 2011. Airborne pollen grains of Gemlik (Bursa). *Asthma Allergy Immunology*, 9: 29-36.

45. Spieksma, F.Th.M. 1990. Pollinosis in Europe: new observations and developments. *Rev. Paleobotany and Palynology*, 64: 35-40.

46. Subiza, J., Cabrera, M., Valdivieso, R., Subiza, J.L., Jerez, M., Jiménez, J.A., Narganes, M.J. & E. Subiza, M.J. 1994. Seasonal asthma caused by airborne *Platanus* pollen. *Clinical and Experimental Allergy*, 24: 1123-1129.

47. Tosunoglu, A., Bicakci, A., Malyer, H. & Sapan, N. 2009. Airborne pollen fall in Koycegiz specially protected area (SW Turkey). *Fresenius Environmental Bulletin*, 18(10): 1860-1865.

48. Tosunoglu A. & Bicakci A. 2015. Seasonal and intradiurnal variation of airborne pollen concentrations in Bodrum. SW Turkey. *Environmental Monitoring and Assessment*, 187(4/167): 1-21.

49. Tosunoğlu, A., Yenigün, A., Bıçakçı, A. & Eliaçık, K. 2013. Airborne pollen content of Kuşadası. *Turkish Journal of Botany*, 37: 297-305.

50. Tosunoglu, A., Altunoglu, M. K., Bicakci, A., Kilic, O., Gonca, T., Yilmazer, I., Saatcioglu, G., Akkaya, A., Celenk, S., Canitez, Y., Malyer, H. & Sapan, N. 2015a. Atmospheric pollen concentrations in Antalya, South Turkey. *Aerobiologia*, 31: 99-109.

51. Tosunoglu, A., Babayigit, S. & Bicakci, A. 2015b. Aeropalynological survey in Buyukorhan, Bursa. *Turkish Journal of Botany*, 39: 40-47.

52. Türe, C. & Böcük, H. 2009. Analysis of airborne pollen grains in Bilecik, Turkey. *Environmental Monitoring and Assessment*, 151: 27-35.

53. Uguz, U., Guvensen, A., Sengonca Tort, N., Esiz Dereboylu, A. & Baran, P. 2018. Volumetric analysis of airborne pollen grains in the city of Uşak, Turkey. *Turkish Journal of Botany*, 42: 57-72.

54. Varela, S., Subiza, J., Subiza, J.L., Rodríguez, R., García, B., Jerez, M., Jiménez, J. & Raphael Panzani, M.D. 1997. *Platanus* pollen as an important cause of pollinosis. *Journal of Allergy and Clinical Immunology*, 100: 748-754.

55. Vergamini, S.M., Barrera, R.M.V., Zoppas, B.C.D.A., Morales, C.P. & Gonzáles, D.F. 2006. Pollen from tree and shrub taxa in the atmosphere of Caxias do Sul (Rio Grande do Sul, Brazil). *Aerobiologia*, 22: 143-150.

56. Villegas, G.J. & Nolla J.M.R. 2001. Atmospheric pollen in Santiago, Chile. Grana. 40: 126-132.

57. Weryszko-Chmielewska, E. & Piotrowska, K. 2004. Airborne pollen calendar of Lublin, Poland. *Annals of Agricultural and Environmental Medicine*, 11: 91-97.