Annals of West University of Timişoara, ser. Biology, 2018, vol. 21 (1), pp.47-56

AIRBORNE POLLEN SPECTRUM OF DOMANİÇ (TURKEY)

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Received 18 April 2018; accepted 9 June 2018

ABSTRACT
A qualitative and quantitative evaluation of pollen fall in the atmosphere of Domaniç (Kütahya) is presented in this study. A continuous aerobiological survey of the atmosphere of Domaniç was carried out from the beginning of 2008 to end of 2010 by means of the gravimetric method using Durham apparatus. Weekly pollen grains in per cm^2 were calculated. During three years, a total of 16 156 pollen grains/ cm^2 which belong to 33 taxa, 22 of total belong to arboreal plants (AP), 11 of total non-arboreal (NAP) plants and unidentified pollen grains were recorded. 3801, 3586, and 8769 pollen grains were recorded in the years 2008, 2009 and 2010 respectively. Total pollen grains consist of 86.23 % AP, 13.38 % NAP plants and 0.39 % unidentified pollen grains. Pinus sp., Cupressaceae/Taxaceae, *Fagus* sp., *Plantago* sp., Poaceae, *Quercus* sp., *Juglans* sp., *Fraxinus* sp. *and Olea* sp. *were responsible for the greatest amounts of pollens in the investigated region. 44.29 % of total pollen grains were appeared during May.*
KEY WORDS: *aeroallergen, aerobiology, Kütahya, pollen fall, pollen calendar.*

INTRODUCTION

In recent years, pollen-related allergies have increased all over the world. Atmospheric pollens are the main cause of allergic diseases (Patz & Kovats 2002). Some pollen grains that cause respiratory system diseases (asthma, hay fever, etc.) are distributed in the atmosphere and can transport long distance (D'Amato *et al.* 1998). Therefore, annual counting and reporting of atmospheric pollens for each region are important. Pollen and mould spores are reported in many developed countries and providing a pollen-spore forecast by national aeroallergen networks or meteorological services play a significant role in the elimination of pollinosis. Studies about the subject have been carried out in all around the world, and annual pollen calendars are prepared in many countries, also (Nilsson *et al.* 1982; Romano *et al.* 1988; Spieksma *et al.* 1989, 1991; D'Amato & Spieksma1990; Thomas *et al.* 1993; Ianovici *et al*. 2015). Aerobiological studies are gradually gaining more importance from year to year. According to aeropalynological studies undertaken in 49 regions of Turkey expressed that the most widespread in number of pollen grains in the atmosphere are Cupressaceae and Poaceae (Bicakci *et al.* 2009; Celenk *et al*. 2010; Kızılpınar *et al.* 2012; Gücel *et al.* 2013; Güvensen *et al.* 2013; Serbes & Kaplan 2014; Cetin *et al.* 2015; Celenk *et al*. 2016; Yalcin *et al.* 2017).

The main aim of this research is to study seasonal pollen grains, pollen concentrations and pollen calendar and to make a quantitative and qualitative analysis of pollen fall belonging

to arboreal and non-arboreal taxa in the Domaniç atmosphere by gravimetric sampling. The three-year pollen calendar was prepared. This study will be contributed to airborne pollen flora of Domaniç in Turkey. The annual pollen concentration results of region presented in this paper may be useful for allergologists to establish an exact diagnosis and patients with pollen allergy.

MATERIALS AND METHODS

Domaniç (Kütahya) is the smallest town with 14 614 inhabitants and situated at 39° 48' N, 29° 36' E with an altitude of approximately 888 m (Fig.1). Domaniç has a rich biological diversity both in terms of species, ecosystem and habitat characteristics. The rainfall in the region is approximately 611 mm (yearly mean). The vegetation consists of pine and beech forests. The main plants in the town are *Pinus nigra, P. nigra* ssp. *pallasina* var. *pyramidata, Quercus pubescens, Q. trojana, Q. cerris, Plantago lanceolata, Tilia tomentosa, Juniperus communis, J. excelsa, J. oxycedrus, Crateagus monogyna, C. orientalis, Cupressus sempervirens, Prunus divaricata, Rosa cannina, Centaurea cyanus, C. virgata, Viola parvula, V. occulata, Tussilago farfara, Acer campestre, Cornus mas, Corylus avellana, Hedera helix, Vibirnum lantana* (Daskin 2008).

This study was carried out using a Durham sampler based on the gravimetric method. The Durham sampler was placed approximately 15 m above ground level. Slides placed in the Durham sampler were stained with glycerine jelly mixed with basic fuchsine (Charpin & Surinyach, 1974), and slides were examined weekly by light microscope. The total weekly counts were converted to pollen grains in cm^2, and a pollen calendar was created for the region. The pollen was counted at 400 × magnification. The study started from the beginning of 2008 and ended the end of 2010. In the calendars, pollen grains were grouped according to REA handbook (Galan *et al.* 2007). Then the number was coloured in the pollen calendar as follows:

Pollen amount lower than one was colored as yellow for *Fagus* sp., *Juglans* sp., *Cedrus* sp., *Mercurialis* sp., *Morus* sp., Apiaceae, *Carpinus* sp., *Lilium* sp., Urticaceae, *Pictacia* sp.. Pollen amount between 1 to 15 was colored as orange for *Fagus* sp., *Fraxinus* sp., *Cedrus* sp., *Juglans* sp., *Mercurialis* sp., *Morus* sp., *Salix* sp., Apiaceae, *Lilium* sp., *Pictacia* sp.. Pollen amount between 16 to 30 was colored as bold-orange for *Juglans* sp., *Mercurialis* sp. and 30 < was coloured as red for *Fagus* sp., *Juglans* sp., *Fraxinus* sp.

Pollen amount lower than one was colored as yellow for Poaceae, *Plantago* sp., Chenopodiaceae, Apiaceae, *Ambrosia* sp., *Rumex* sp., Ericaceae. Pollen amount between 1 to 25 was coloured as orange for Poaceae, *Plantago* sp., Chenopodiaceae, Apiaceae, *Ambrosia* sp., *Rumex* sp., Ericaceae. Pollen amount between 26 to 50 was colored as bold-orange for Poaceae, *Plantago* sp. and 50 < was colored as red for *Plantago* sp.

Pollen amount lower than one was coloured as yellow for *Corylus* sp., *Alnus* sp., *Ulmus* sp., *Castanea* sp. Pollen amount between 1 to 30 was coloured as orange for *Corylus* sp., *Alnus* sp., *Betula* sp., *Acer* sp., *Castanea* sp. Pollen amount lower than one was coloured as yellow for *Pinus* sp., Cupressaceae, *Quercus* sp. Pollen amount between 1 to 50 was coloured as orange for *Pinus* sp., Cupressaceae, *Quercus* sp., *Platanus* sp.,*Olea* sp.; pollen amount between 51 to 200 was coloured as bold-orange for *Pinus* sp., Cupressaceae, *Quercus* sp. *and* 200 < was coloured as red for *Pinus* sp.

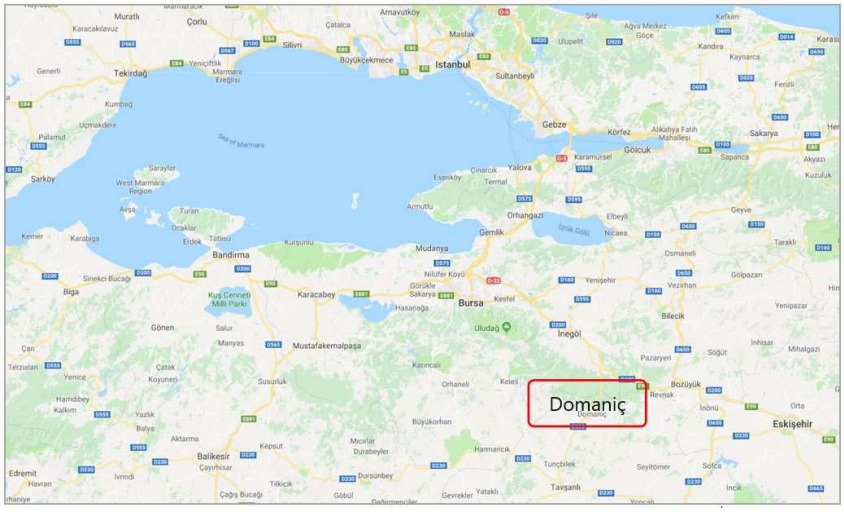


FIG. 1. Place of the investigated region (Domaniç).

RESULTS AND DISCUSSIONS

During the three yearly periods (2008-2010), a total of 16156 pollen grains from 33 taxa, 3801 in 2008, 3586 in 2009 and 8769 in 2010, have been identified in the atmosphere of Domaniç (Table 1). Out of 33 taxa, 22 were arboreal while the others were non-arboreal plants. Of the total pollen grains, 86.23% were arboreal, 13.38% non-arboreal and 0.39% unidentified (Table 1). The best-represented pollen type throughout the studying period was *Pinus* sp., which attained 51.96% of the annual total (Table 1). Other allergen pollen types represented in the atmosphere of Domaniç, accounting for 42.17% as a whole identified pollen grains, where: Cupressaceae/Taxaceae*,* *Fagus* sp*.,* *Plantago* sp., Poaceae*,* *Quercus* sp*.,* *Juglans* sp*.,* *Fraxinus* sp. and *Olea* sp. The highest percentages in relation to the annual total were obtained from March to June and peaked in May. The monthly variation of arboreal and non-arboreal pollen concentrations are given in Figure 2. The types of pollens present in the atmosphere of Domaniç are shown in figure 3 which based on the mean counts made in three yearly periods.

Pollen grains from March to June accounted for 91.08% of the recorded total pollen (Table 2). High pollen concentration was obtained during springtime.

The main pollen producers in the atmosphere of Domaniç were the following plants: *Pinus* sp. (51.96%), Cupressaceae/Taxaceae (13.62%)*,* *Fagus* sp. (8.20%), *Plantago* sp. (5.45%)*,* Poaceae (5.08%)*,* *Quercus* sp. (4.80%), *Juglans* sp. (2.15%)*,* *Fraxinus* sp.(1.87%) and *Olea* sp. (1.00%). They form 94.13% of the total pollen fall (Table 1-2).

From herbaceous plants, *Plantago* sp. (5.45%) and Poaceae (5.08%) were the most important pollen in the atmosphere of Domaniç (Table1-2). The season of maximum pollen concentration for *Plantago* sp. was identified between the last week of May to the first week of July. The season of maximum pollen concentration for Poaceae was identified as June.

A noticeable change in monthly pollen composition was observed during the sampling period (Figs.2-3). The earliest pollen grains in the atmosphere of Domaniç were noted as

Pinus sp. in January (Table 2, Fig.3). The number of *Pinus* sp. pollen grains increased from April to June (48.95 %) and reached its maximum level in May (37.59%) (Table 2, Figs.2-3).

In May, 17 taxa were identified, and 11 of them belong to AP. *Pinus* sp. (37.59%), Poaceae (1.25%), *Fagus* sp. (1.18%), Cupressaceae/Taxaceae (1.02%) were releasing high amounts of pollen into the atmosphere throughout their pollination period and formed more than 90% of the total pollen grains in May (Table 2).

In June, 15 pollen taxa (8 AP and 7 NAP) were founded in the atmosphere of Domaniç. *Pinus* sp. dominated in the pollen spectrum of Domaniç in June. Also, pollen grains of *Plantago* sp. (2.81%) were identified as a high amount in June (Table 2).

In July, the number of pollens was lower than it was in springtime and early summer. The reason for this decrease was correlated with the end of the pollination periods of many AP which released high amounts of pollen into the air. Ten taxa (3 of them AP) were found in July (Fig.3).

In August, ten taxa were identified (3 of them AP). The lowest pollen grains were recorded August and September. October, November and December were aeroallergen free months.

The followings are the nine taxa which produced the greatest amount of pollens in the atmosphere of Domaniç:

***Pinus* sp.:** Pollen grains of this genus constituted 51.96% of total pollen in the atmosphere of Domaniç (Tables 1-2). The pollen season started the second week of January (2^{nd} week) and lasted the fourth week of October (43^{rd} week). The highest counts were recorded from the first week of May to last week of June (18^{th} - 23^{rd} week of the year) (Fig.4-A).

Cupressaceae / Taxaceae: Pollen grains of this family constituted 13.62% of total pollen in the atmosphere of Domaniç (Tables 1-2). The pollen season was started the third week of January and lasted the fourth week of December (3^{rd}-52^{nd} week of the year) (Figs.4-B).

***Fagus* sp.:** Pollen grains of this genus constituted 8.20% of total pollen in the atmosphere of Domaniç (Tab. 1-2). Pollen season started the second week of March and lasted the third week of September (10^{th} – 38^{th} week of the year) (Figs. 3). The highest counts were recorded from the first week of April to last week of May (14^{th} -18^{th} week of the year) (Figs.4-C)

***Plantago* sp.:** Pollen grains of this genus constituted 5.45% of total pollen in the atmosphere of Domaniç (Tables 1-2). The pollen season started in the first week of April and ended in the last week of September (14^{th} - 39^{th} week of the year) (Figs.4-D).

Poaceae: Pollen grains of this family constituted 5.08% of total pollen in the atmosphere of Domaniç (Tables 1-2). Pollen grains were recorded during the greater part of the year. The pollen season started in the third week of February and ended in the last week of October (7^{th}- 40^{th} week). (Figs.4-E)

***Quercus* sp.:** Pollen grains of this genus constituted 4.80% of total pollen in the atmosphere of Domaniç (Tab. 1-2). Pollen production was continued from the last week of March (13^{th} week) to the first week of June (22^{nd} week) (Figs.4-F).

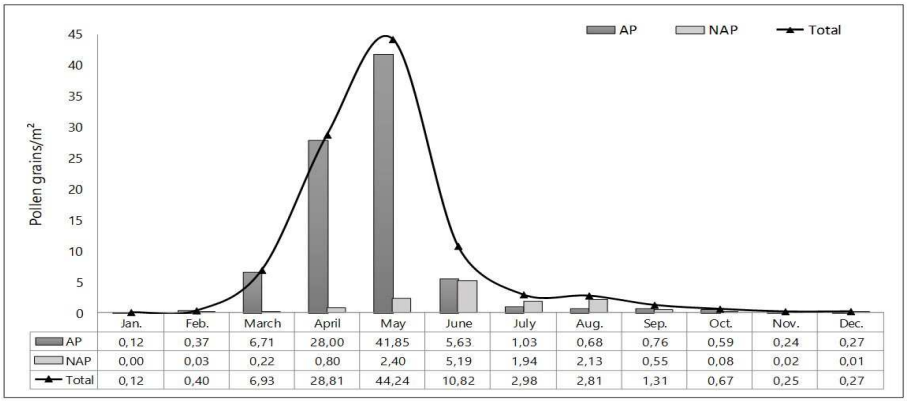
***Juglans* sp.:** Pollen grains of this family constituted 2.15% of total pollen in the atmosphere of Domaniç (Tables 1-2). Pollen production of this family started in the fifth week of March (13^{th} week of the year) and ended last week of May (27^{th} week of the year) (Figs.4-G).

***Fraxinus* sp.:** Pollen grains of this family constituted 1.87% of total pollen in the atmosphere of Domaniç (Tables 1-2). The pollen season started in the second week of March

(10^{th} week of the year) and ended in the last week (18^{th} week) of May (Fig. 3). The highest counts were recorded from the fifth week of March to last week of April (13^{th} - 17^{th} week of the year) (Fig.4-H).

***Olea*:** Pollen grains of this genus constituted 1.00 % of total pollen in the atmosphere of Domaniç (Tables 1-2). The pollen season started the fourth week of April (17^{th} week) and lasted the second week of June (23^{rd} week) (Fig.4-H).

The types of airborne pollen grains and pollen allergy show variation all over the world, depending on the countries and climates. Allergenicity and threshold values for all allergenic pollens change according to both biological and environmental conditions. The most important allergenic species on the Mediterranean regions and around are Cupressaceae, Poaceae and *Olea* species. Also *Platanus* sp., *Quercus* sp. and *Fraxinus* sp. species may have importance as seconder dominant species in the air. The floral composition of the investigated region mainly reflects the Mediterranean vegetation. Pollen data were collected in Domaniç for three years (2008-2010) and a total of 16156 pollen grains belonging to 33 taxa were identified. Of these, 22 are arboreal herbaceous plants (AP) and 11 are non-arboreal (NAP) plants. The similar pollen calendar was created for Tavşanlı and distance between Tavşanlı and Domaniç is far away from each other 39 km. In Tavşanlı, pollen data were collected for two years (2003-2004) and a total of 17079 pollen grains belonging to 52 taxa were recorded. 25 of them belong to the arboreal plants (AP), 27 belong to the non-arboreal (NAP) plants. For Domaniç, 86.23% of the collected taxa were recorded as arboreal (AP), 13.38% as non-arboreal (NAP), and 0.39% as unidentified taxa. In Tavşanlı, it was determined that the taxa collected in two years were 88.46% arboreal (AP), 9.67% non-arboreal (NAP) and 1.78% unrecognised taxa. Pollen of some plants such as Cupressaceae/Taxaceae*, Fagus* sp*., Plantago* sp*.,* Poaceae*, Quercus* sp., *Juglans* sp., *Fraxinus* sp. *and Olea* sp. were found in high concentrations in Domaniç. According to the study done in the nearest region, Tavşanlı, pollen grains of *Pinus* sp., Cupressaceae/Taxaceae, *Quercus* sp., Poaceae, *Platanus* sp., *Salix* sp., Moraceae and Oleaceae are the main species in the air.



	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
AP	0,12	0,37	6,71	28,00	41,85	5,63	1,03	0,68	0,76	0,59	0,24	0,27
NAP	0,00	0,03	0,22	0,80	2,40	5,19	1,94	2,13	0,55	0,08	0,02	0,01
Total	0,12	0,40	6,93	28,81	44,24	10,82	2,98	2,81	1,31	0,67	0,25	0,27

FIG. 2. Monthly total variation in pollen grains in the atmosphere of Domaniç, 2008-2010.

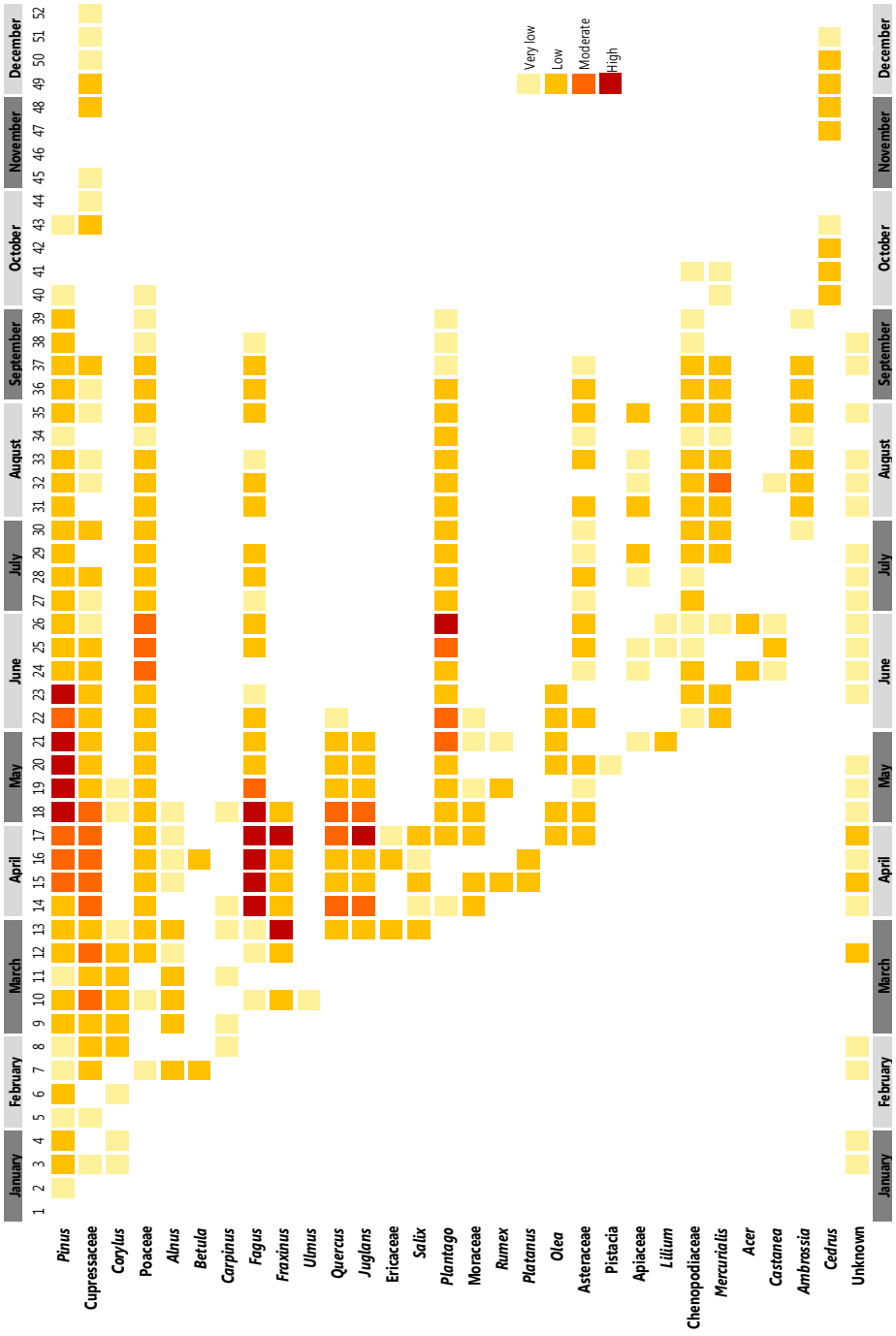


FIG. 3. Pollen calendar with all pollen types for Domaniç

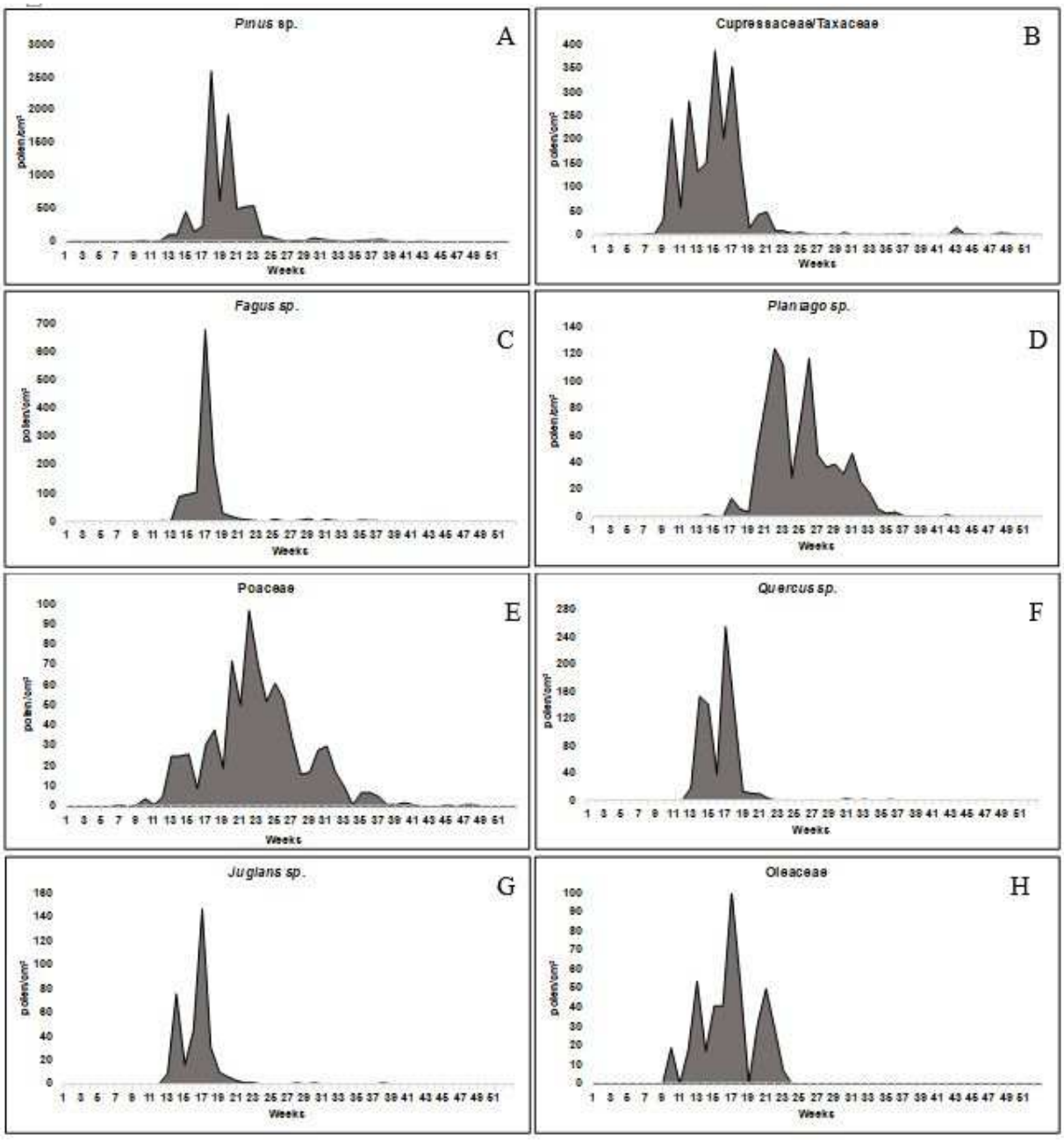


FIG. 4. Weekly total of the pollen concentrations recorded in Domaniç during three years, 2008-2010.

TABLE 1. Annual totals of pollen counts of Domaniç, 2008-2010.

		2008	2009	2010	TOTAL	%
Arboreal Plants	*Pinus*	1776	1082	5536	8394	51,96
	Cupressaceae	533	608	1060	2201	13,62
	Fagus	231	229	865	1325	8,20
	Quercus	71	398	306	775	4,80
	Juglans	71	119	158	348	2,15
	Fraxinus	81	106	115	302	1,87
	Olea	79	1	82	161	1,00
	Cedrus	44	19	71	134	0,83
	Corylus	29	19	4	52	0,32
	Moraceae	10	22	18	50	0,31
	Alnus	19	10	9	38	0,24
	Acer	31	1	0	32	0,20
	Salix	10	16	2	28	0,17
	Platanus	0	22	0	22	0,14
	Carpinus	7	6	4	17	0,11
	Ericaceae	2	12	1	15	0,09
	Castanea	6	8	0	14	0,09
	Betula	2	3	7	12	0,07
	Ulmus	1	0	4	5	0,03
	Pistacia	1	2	0	3	0,02
	Populus	2	0	0	2	0,01
	Ostrya	1	0	0	1	0,01
	Total (AP)	**3007**	**2682**	**8242**	**13931**	**86,23**
Non-arboreal Plants	*Plantago*	316	317	247	880	5,45
	Poaceae	301	279	240	820	5,08
	Mercurialis	6	116	13	135	0,84
	Chenopodiaceae	44	89	1	134	0,83
	Asteraceae	47	22	8	77	0,48
	Ambrossia	29	31	0	60	0,37
	Apiaceae	11	14	0	25	0,15
	Rumex	7	7	0	14	0,09
	Lilium	4	1	5	10	0,06
	Urticaceae	5	0	0	5	0,03
	Artemisia	0	1	0	1	0,01
	Total (NAP)	**770**	**877**	**514**	**2161**	**13,38**
	Unidentified	24	26	13	63	0,39
	TOTAL	**3801**	**3586**	**8769**	**16156**	**100,00**

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
Pinus sp.	0,07	0,07	0,89	6,28	37,59	5,08	0,76	0,51	0,66	0,03	-	-	51,96
Cupressaceae	0,02	0,08	4,60	7,42	1,02	0,17	0,06	0,02	0,03	0,12	0,04	0,05	13,62
Fagus sp.	-	0,02	0,05	6,54	1,18	0,09	0,15	0,09	0,05	0,02	-	-	8,20
Plantago sp.	-	-	-	0,11	0,93	2,81	1,02	0,51	0,06	0,01	-	-	5,45
Poaceae	-	0,01	0,22	0,57	1,25	2,02	0,53	0,32	0,12	0,02	0,02	-	5,08
Quercus sp.	-	-	0,11	3,74	0,92	-	0,01	0,01	0,01	-	-	-	4,80
Juglans sp.	-	-	0,06	1,89	0,18	0,01	0,01	-	0,01	-	-	-	2,15
Fraxinus sp.	-	-	0,56	1,31	-	-	-	-	-	-	-	-	1,87
Olea sp.	-	-	-	0,11	0,85	0,04	-	-	-	-	-	-	1,00
Others	0,02	0,22	0,44	0,84	0,32	0,59	0,43	1,36	0,37	0,47	0,20	0,22	5,48
Unidentified	0,01	0,01	0,07	0,12	0,05	0,05	0,02	0,04	0,02	0,01	-	-	0,39
TOTAL	**0,13**	**0,41**	**7,00**	**28,92**	**44,29**	**10,87**	**3,00**	**2,85**	**1,32**	**0,68**	**0,25**	**0,27**	**100,00**

TABLE 2. Percentage of the highest airborne pollen grains in the atmosphere of Domaniç (grey: monthly values higher than 1%).

In the atmosphere of Domaniç, arboreal pollen types were dominant. The frequency of arboreal pollen grains generally depends on the distribution and density of the local vegetation and rate of pollen production. According to the other studies, arboreal pollen types are also dominant in many regions like Tavsanli (88.46%) (Celenk *et al*. 2016), Finland (82%) (Koivikko *et al.*1986), Denizli (79.68%) (Güvensen *et al.* 2013), Nicosia (78.76%) (Gücel *et al.* 2013), Poland (73%) (Kasprzyk 1996), Perugia (71%) and Ascoli Piceno (55%) (Romano *et al.* 1988), Afyon (69.67%) (Bicakci *et al.* 2002), Düzce (66.60%) (Serbes & Kaplan 2014), Konya (61.29%) (Kızılpınar *et al.* 2012), Ardahan (50.63%) (Cetin *et al.* 2015), Kars (25.70%) (Yalcin *et al.*2017).

CONCLUSIONS

As a conclusion, Cupressaceae is the main suspect of pollen allergy in the region with the 13.62% ratio in the all airborne pollen spectrum. Another important point for Cupressaceae is releasing of pollen grains all around the year in the atmosphere like many regions in the Mediterranean area (Hidalgo *et al.* 2003). The second important aeroallergens in the investigated area are Fabaceae pollen grains. The ratio of the Fabaceae family member in the pollen spectra is 13.09%. Although birch group allergens were identified less than 1% in the atmosphere, cross-reactivity between birch and beech was reported (Horak *et al.* 1979; Ericsson *et al.* 1984). Allergic sensitisation to pollen grains of Fagaceae family member must be taken into account, and allergen extract from beech family members may be placed in the prick test panels with the Cupressaceae pollen extracts. Pollen grains of 33 taxa were determined during the pollen season in the atmosphere of Domaniç, 9 of them formed about 94.13% of the spectrum, and 39.05% of annual pollen grains have importance for allergological point of view. This percentage is lower than another area where nearest to the investigated region and may have a reason preferring for a vacation for sensitive people. Pollen grains in the atmosphere were examined within three years and reached maximum levels in May. Pollen calendars and detailed data about the aeroallergens presented here may be useful for allergy specialist and patients with pollen allergy.

Acknowledgement We would like to thank Meliha KATAĞAN for slide changing during the studying period.

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