Pak. J. Bot., 53(2): 621-630, 2021. DOI: http://dx.doi.org/10.30848/PJB2021-2(6)

POLLEN SPECTRUM AND THE EFFECTS OF WEATHER VARIABLES ON MAIN POLLEN TYPES IN DIKILI (TURKEY) ATMOSPHERE

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Abstract

Atmospheric pollen grains were surveyed with the gravimetric method between 2015 and 2016 in Dikili (Turkey). Annually 6986 pollen grains, belonging to 47 plant taxa were identified; pollen grains of woody taxa consisted of 80.31% of the annual pollen index, which was found concordant and evaluated as a reflection of the dominant flora of the area. Pollen types belonging to *Pinus*, *Quercus*, *Olea europaea*, Poaceae, Cupressaceae/Taxaceae, *Fraxinus*, *Ambrosia*, *Plantago*, *Platanus*, *Pistacia*, and Amaranthaceae were classified as dominant pollen types for the region and the total amount for them were 91.95% of the annual pollen index. The highest pollen count in the year was recorded in the month of April. April-May months are the pollination periods and can be thought of as a risky period for sensitive individuals for the region. One of the most exciting findings of this study was about the high levels of allergenic *Ambrosia* pollen in the atmosphere. This was the first reported of the airborne pollen of rageweed as a dominant pollen type in Turkey. Statistical analyses revealed the effects of meteorological factors on weekly pollen concentrations of dominant pollen types, and many significant correlations were found.

Key words: Pollen fall, Airborne pollen, Pollen sampling, Aegean, Anatolia.

Introduction

Pollen grains are atmospheric bio-organic aerosols, most of which are classified as respiratory allergens. Pollen allergy is a known world plague on human health. It is becoming more critical day by day with the increase of pollen sensitive individuals, especially those who are living in developed countries and urbanized regions. For this reason, many studies have been designed for atmospheric pollen monitoring, and many researchers have focused on the regional modeling and allergen pollen forecasts in many regions around the world (Keynan *et al*., 1991; Kobzar *et al*., 1999; Ballero & Maxia, 2003; Gioulekas *et al*., 2004; Mandal *et al*., 2008; Melgar *et al*., 2012; Hadj Hamda *et al*., 2017).

Besides the fact that atmospheric pollen is mostly allergenic, it is crucial botanically that the aeropalynological studies carried out on a regional basis also give an idea about the phenology of wind-pollinated plants. Atmospheric pollen diversity of any region is based on the flora and vegetation of the region, as well as its geographical features and predominant meteorological parameters. Phenological studies require the determination of phenophases of plants; hence frequent sampling is inevitable for a geographical region, such as the Anatolian peninsula, which has a large number of microclimatic areas. Therefore, separate atmospheric pollen monitoring studies are required for each region. For this purpose, atmospheric pollen studies were initiated for the first time in Ankara-Turkey (Karamanoglu & Ozkaragoz 1967), continued for an extended period of time (Bicakci & Akyalcin, 2000; Tosunoglu *et al*., 2013; Kaplan & Ozdogan, 2015; Acar *et al*., 2015; Potoglu Erkara *et al*., 2016) Although the present studies mostly focus on the volumetric method, it should be noted that the studies carried out with the gravimetric method are now up-to-date and are used in various recent studies (Bicakci, 2006; Altunoglu *et al*., 2010; Kishikawa *et al*., 2016; Werchan *et al*., 2017), and constitute an important source for reflecting the general atmospheric pollen profile for the regions having no previous data.

In this study, atmospheric pollen spectrum for Dikili (İzmir) province, located on the coast of Aegean Sea was conducted to determine (1) the pollen types and their quantity, (2) to find pollen seasons of primary pollen producers and (3) to determine the relationship between weekly pollen concentrations and meteorological factors.

Material and Methods

Study region, flora, and climate: Dikili is situated at 39º4'32'' N and 26º 53'21'' E in the western part of the Anatolian Peninsula; on the coast of the Aegean Sea, on the southern slope of the mount Kazdağı, and the north of İzmir. According to the first archaeological information, Dikili is a historical place (the ancient name is Aterneus) dates back to BC.4000-5000 years. In the early ages, Lydians, Persians, Phrygians and Mysians, then Romans, Bergamans, Byzantines in the middle ages, Genoese, Seljuks and finally Ottomans were dominant in the region. Nowadays, Dikili is a well-known tourism center with historical places and holiday tourism (Fig. 1).

The study area exhibits a Mediterranean climate, and maquis elements are dominant in the region, including *Olea europaea* L. var. *sylvestris* (Miller) Lehr., *Quercus coccifera* L., *Quercus aucheri* Jaub. et Spach, *Platanus orientalis* L., *Pistacia lentiscus* L., *Pistacia terebinthus* L., *Arbutus andrachne* L., *Laurus nobilis* L., *Vitex agnus-castus* L. *Cistus creticus* L., *Cistus salviifolius* L., *Erica manipuliflora* Salisb., *Styrax officinalis* L., *Myrtus communis* L., *Nerium oleander* L., *Spartium junceum* L., *Phillyrea latifolia* L., *Sarcopoterium spinosum* (L.) Spach, *Satureja thymbra* L., and *Thymbra spicata* L.. The slopes of hills are covered with *Pinus brutia* Ten and additionally, commonly cultivated plants like, *Olea europaea* L., *Pinus pinea* L., *Ficus carica* L., *Tilia argentea* (L.) Moench. and *Nicotiana tabacum* L. can be seen frequently in the study area.

Fig. 1. Location map of Dikili, Turkey.

In our study, meteorological factors were evaluated for two sampling years with the data provided by the Ministry of Forestry and Water Management, Turkish State Meteorological Service. According to the average values during the sampling period; January was the coldest month with 8.27ºC, August is the hottest 27.21ºC, January is the rainiest month with 138.60 mm total precipitation, July was the driest with no precipitation and the lowest in relative humidity (50.16%), January had maximum dew (71.04%).

Aeropalynological study: In this study, from the beginning of January 2015 to the end of December 2016, Durham apparatus, used for the gravimetric studies, was placed at the height of 9 m above the ground level. The weekly slides were covered with glycerin-jelly mixed with basic fuchsine (Charpin *et al*., 1974) and counting was done on a 24 x 24 mm area of the slide, which was extrapolated to 1 cm^2 later; all pollen amounts given for per cm^2. Pollen types that comprised more than 1% of the annual pollen sum were considered as predominated types. The pollen grains from unknown types were classified as unidentified types.

Statistical analysis

The Kolmogorov-Smirnov test was applied to the weekly data for normality testing and negative results were found (p <0.05). Spearman's correlation analysis was performed to correlate the weekly pollen amounts of dominated pollen types (*Pinus, Quercus, Olea europaea,* Poaceae, Cupressaceae/Taxaceae, *Fraxinus*, *Ambrosia*, *Plantago*, *Platanus*, *Pistacia,* and Amaranthaceae) with the concurrent data of meteorological parameters (mean weekly relative humidity, mean weekly temperature, mean weekly wind speed and weekly total rainfall) using the same day data. To compare the two sampling years in terms of pollen amounts of dominated taxa, and meteorological parameters, nonparametric Mann–Whitney *U* test was prepared with the 95% of the confidence interval. The statistical analyses were performed using the software package IBM SPSS version 22.0 (SPSS-Chicago, Illinois, USA).

Results

A total of 13972 pollen grains biennially was recorded for per cm^2 according to gravimetric sampling in the Dikili atmosphere; annually, 6986 pollen grains (6779 in 2015 and 7193 in 2016) belonging to 47 taxa (26 woody and 21 herbaceous taxa) were identified. Pollen grains of woody taxa consisted of 80.31% (78.86% in 2015 and 81.76% in 2016), and herbaceous taxa represented 19.51% (20.90% in 2015 and 18.11% in 2016) of the annual pollen index (API) (Table 1).

The amount of pollen in the Dikili atmosphere started to increase since January 2015, when the sampling began. The gradual and regular increase in the amount of pollen has been folded in April and May and reached the maximum pollen level in May in 2015 (Fig. 2). Until May, there was direct correlation in the increase of temperature and the pollen amount but, in the case of precipitation, despite the heat, there was a gradual decline. With the decrease in heavy rainfall, which was observed in April, the amount of pollen was reached to the highest level in May in 2015. However, after May, the amount of pollen in the atmosphere began to decrease rapidly due to the change of pollinating taxa and the coming summer heat (Fig. 2). With the completion of pollination periods of spring pollinating trees, more pollen grains of herbaceous plants (e.g., Poaceae, Amaranthaceae, *Plantago*, etc.) were found in the atmosphere during the summer months (Table 2). The decrease in the amount of pollen was continued until the end of the first sampling year. Similar to the first year, the amount of pollen began to increase again in 2016, but this amount was reached its highest level in April, unlike the previous year. The heavy rainfall in April of the first year was recorded as 1/10 of the second year (Fig. 2). Also, monthly mean temperatures in the 2^{nd} year were recorded as about 3ºC higher than in the first year. In the first sampling year, the average monthly temperature reached 20ºC in May; but in the second year, this value was in June. The amount of pollen in the atmosphere was gradually decreased after April of the second year, and this decline was continued throughout the summer. The increase in the amount of pollen in August was the pollination period of Ambrosia. In the autumn and winter, the amount of pollen was dropped to the lowest levels, as in the previous year (Fig. 2).

When monthly pollen percentages are taken into account according to the average values, the highest concentration of pollen in the Dikili atmosphere was recorded in April (36.01% of the mean annual pollen index), although it varied between years (42.98% of the annual pollen index in May 2015, 42.12% in April 2016) (Table 2). However, statistically, no significant difference was found (p>0.05) in terms of total pollen amounts, pollen quantities of each taxon, and meteorological parameters between two years, except relative humidity.

According to the two years' average, eleven plant taxa contributed to more than 1% of the total pollen content and were taken as the predominant pollen types with the most significant influence in Dikili atmosphere which included *Pinus* (26.54%), *Quercus* (23.45%), *Olea europaea* (14.18%), Poaceae (11.33%), Cupressaceae/ Taxaceae (7.75%), *Fraxinus* (2.10%), *Ambrosia* (1.58%), *Plantago* (1.54%), *Platanus* (1.23%), *Pistacia* (1.16%) and Amaranthaceae (1.10%) These eight dominated taxa represented 91.95% of the mean annual pollen index (Table 1).

For the dominant pollen types identified in the study, the main pollen seasons, and durations were based on weekly data (Table 3). As the main contributors, the longest main pollen seasons were of Cupressaceae/ Taxaceae and Poaceae families. On the other hand, the shortest pollen season was recorded for *Platanus* and *Ambrosia*. When the dominant pollen types and significant components in the atmosphere were examined, it was found that the Cupressaceae/ Taxaceae pollen were found in the atmosphere throughout the year except for July and August. *Fraxinus* and Cupressaceae/ Taxaceae pollen were recorded as the earliest pollen types in early spring. Of the herbaceous plants, Poaceae pollen was recorded in the atmosphere since February due to its early flowering (Table 2). *Ambrosia* and Amaranthaceae pollen grains were recorded as the latest pollen types reaching maximum density in late summer in the atmosphere. One of the most exciting findings was that the pollen of invasive species, *Ambrosia*, which was extensively distributed in Europe, was recorded among the dominant pollen in Dikili atmosphere (Table 2); this is the first report, the airborne ragweed pollen as dominant in Turkey.

The highest number of pollen grains in the atmosphere in 2015 was recorded in the 19th week, and the mean relative humidity in this week was the lowest of the year. However, in the second sampling year, higher atmospheric pollen were recorded in the 13th week, i. e. six weeks earlier than the previous year (Table 2).

Statistically, Mann–Whitney *U* test showed that comparison in weekly pollen amounts of dominant pollen types, as well as meteorological parameters, were not found significantly different (p>0.05) between two sampling years. Spearman's correlation analysis showed that: the amounts of pollen belonging to woody plants were not affected by the parameters such as total weekly rainfall, average relative humidity and average wind speed in every two years. However, significant positive correlation was observed between the weekly mean temperature and the amount of woody plant pollen in the second sampling year. The weekly quantities of herbaceous plants' pollen showed significant negative correlations with total weekly rainfall, mean relative humidity, and mean weekly temperature in the first sampling year. In contrast, significant positive relationships were observed with the mean weekly wind speed and negative correlations with mean relative humidity in the second year (Table 3).

When the correlations between weekly amounts of dominant pollen types and weekly meteorological parameters were examined; significant negative correlations were found between Cupressaceae/Taxaceae pollen and mean temperature for both years. Also, significant positive correlations were found between *Olea europaea*, Poaceae, *Ambrosia*, *Plantago*, and Amaranthaceae pollen and weekly mean temperature for both years. Poaceae pollen only showed a significant negative correlation with rainfall in the first sampling year, However, *Ambrosia* and Amaranthaceae pollen showed negative correlation with rainfall in both years whereas Cupressaceae/Taxaceae while *Fraxinus* showed a significant positive correlation with total precipitation in the second sampling year. *Pinus*, *Olea europaea* and Poaceae pollen showed significant negative correlations with relative humidity in the first year, *Ambrosia* pollen showed negative correlation in the second year and Amaranthaceae pollen in both years, while Cupressaceae/ Taxaceae pollen showed significant positive correlations only in the second year with moisture as in rainfall. The wind speed in the Dikili was generally not found effective on pollen of most of the taxa only significant positive correlation was recorded between the Cupressaceae/ Taxaceae pollen and the mean wind speed in the second year (Table 3).

Table 1. Total amount of airborne pollen grains for each taxon in Dikili atmosphere in years 2015-16 (Mean and percentage values).

	2015	%	2016	%	Mean	%
Pinus	***1812***	***26,73***	***1895***	***26,35***	***1854***	***26,54***
Quercus	***1410***	***20,80***	***1877***	***26,09***	***1644***	***23,45***
Olea	***1071***	***15,80***	***903***	***12,55***	***987***	***14,18***
Cupressaceae/Taxaceae	***516***	***7,61***	***567***	***7,88***	***542***	***7,75***
Fraxinus	***124***	***1,83***	***170***	***2,36***	***147***	***2,10***
Platanus	***72***	***1,06***	***100***	***1,39***	***86***	***1,23***
Pistacia	***57***	***0,84***	***107***	***1,49***	***82***	***1,16***
Abies	81	1,19	9	0,13	45	0,66
Acer	26	0,38	58	0,81	42	0,59
Betula	25	0,37	34	0,47	30	0,42
Populus	29	0,43	19	0,26	24	0,35
Morus	14	0,21	25	0,35	20	0,28
Ulmus	27	0,40	10	0,14	19	0,27
Salix	5	0,07	24	0,33	15	0,20
Tilia	9	0,13	14	0,19	12	0,16
Castanea	12	0,18	7	0,10	10	0,14
Alnus	12	0,18	6	0,08	9	0,13
Juglans	4	0,06	13	0,18	9	0,12
Laurus nobilis	10	0,15	4	0,06	7	0,10
Carpinus	3	0,12	10	0,07	7	0,09
Ericaceae	8	0,09	5	0,10	7	0,09
Rosaceae	6	0,04	7	0,14	7	0,09
Cedrus	5	0,07	6	0,08	6	0,08
Celtis	4	0,06	6	0,08	5	0,07
Eucalyptus	2	0,03	3	0,04	3	0,04
Aesculus	2	0,03	2	0,03	2	0,03
Woody Plants	**5346**	**78,86**	**5881**	**81,76**	**5614**	**80,31**
Poaceae	***860***	***12,69***	***718***	***9,98***	***789***	***11,33***
Ambrosia	***100***	***1,48***	***121***	***1,68***	***111***	***1,58***
Plantago	***81***	***1,19***	***136***	***1,89***	***109***	***1,54***
Amaranthaceae	***78***	***1,15***	***76***	***1,06***	***77***	***1,10***
Rumex	86	1,27	49	0,68	68	0,97
Asteraceae	29	0,43	57	0,79	43	0,61
Xanthium	34	0,50	17	0,24	26	0,37
Cichorioideae	12	0,18	35	0,49	24	0,33
Poterium	20	0,30	23	0,32	22	0,31
Urticaceae	27	0,40	10	0,14	19	0,27
Typha	25	0,37	8	0,11	17	0,24
Cyperaceae	20	0,30	12	0,17	16	0,23
Cannabaceae	6	0,09	11	0,15	9	0,12
Apiaceae	7	0,12	7	0,08	7	0,10
Brassicaceae	8	0,10	6	0,10	7	0,10
Artemisia	8	0,12	4	0,06	6	0,09
Fabaceae	8	0,12	4	0,06	6	0,09
Juncaceae	3	0,04	2	0,03	3	0,04
Lamiaceae	3	0,04	2	0,03	3	0,04
Campanulaceae	1	0,01	3	0,04	2	0,03
Boraginaceae	1	0,01	2	0,03	2	0,02
Herbaceous plants	**1417**	**20,90**	**1303**	**18,11**	**1360**	**19,51**
Unidentified	16	0,24	9	0,13	13	0,18
Total	**6779**	**100,00**	**7193**	**100,00**	**6986**	**100,00**

Table 2. Monthly variation of dominant pollen types ant their monthly change in Dikili atmosphere during the years 2015-2016.

		January	February	March	April	May	June	July	August	September	October	November	December	Total
Pinus	2015	0.00	0.00	0.09	9.40	12.80	3.98	0.41	0.04	0.00	0.00	0.00	0.00	26.73
	2016	0.00	0.00	8.34	11.51	5.55	0.72	0.15	0.07	0.00	0.00	0.00	0.00	26.35
	Mean	0.00	0.00	4.21	10.45	9.18	2.35	0.28	0.06	0.00	0.00	0.00	0.00	26.54
Quercus	2015	0.00	0.00	0.01	13.28	7.15	0.35	0.00	0.00	0.00	0.00	0.00	0.00	20.80
	2016	0.00	0.00	8.62	16.93	0.51	0.03	0.00	0.00	0.00	0.00	0.00	0.00	26.09
	Mean	0.00	0.00	4.32	15.10	3.83	0.19	0.00	0.00	0.00	0.00	0.00	0.00	23.45
Olea europaea	2015	0.00	0.00	0.00	0.03	13.76	1.87	0.12	0.01	0.00	0.00	0.00	0.00	15.80
	2016	0.00	0.00	0.00	5.78	6.56	0.17	0.04	0.00	0.00	0.00	0.00	0.00	12.55
	Mean	0.00	0.00	0.00	2.91	10.16	1.02	0.08	0.01	0.00	0.00	0.00	0.00	14.18
Cupressaceae/ Taxaceae	2015	0.12	2.58	3.33	0.65	0.32	0.12	0.03	0.00	0.00	0.13	0.31	0.01	7.61
	2016	0.24	3.77	2.34	1.33	0.07	0.06	0.04	0.00	0.00	0.00	0.03	0.01	7.88
	Mean	0.18	3.17	2.83	0.99	0.20	0.09	0.04	0.00	0.00	0.07	0.17	0.01	7.75
Fraxinus	2015	0.00	0.01	1.36	0.44	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.83
	2016	0.00	0.49	1.85	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.36
	Mean	0.00	0.25	1.60	0.24	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.10
Platanus	2015	0.00	0.00	0.03	0.87	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06
	2016	0.00	0.00	0.82	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39
	Mean	0.00	0.00	0.42	0.72	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23
Pistacia	2015	0.00	0.00	0.00	0.38	0.44	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.84
	2016	0.00	0.00	1.32	0.15	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.49
	Mean	0.00	0.00	0.66	0.27	0.23	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.16
Poaceae	2015	0.00	0.00	0.19	1.34	5.44	2.55	1.73	0.74	0.34	0.34	0.01	0.00	12.69
	2016	0.00	0.01	0.68	2.34	4.82	1.11	0.29	0.38	0.19	0.15	0.00	0.00	9.98
	Mean	0.00	0.01	0.44	1.84	5.13	1.83	1.01	0.56	0.27	0.25	0.01	0.00	11.33
Ambrosia	2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.59	0.01	0.00	0.00	1.48
	2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.43	0.22	0.03	0.00	0.00	1.68
	Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.41	0.02	0.00	0.00	1.58
Plantago	2015	0.00	0.00	0.00	0.43	0.50	0.16	0.09	0.00	0.01	0.00	0.00	0.00	1.19
	2016	0.00	0.00	0.18	0.72	0.57	0.28	0.10	0.04	0.00	0.00	0.00	0.00	1.89
	Mean	0.00	0.00	0.09	0.58	0.54	0.22	0.09	0.02	0.01	0.00	0.00	0.00	1.54
Amaranthaceae	2015	0.00	0.00	0.00	0.00	0.04	0.09	0.18	0.32	0.46	0.06	0.00	0.00	1.15
	2016	0.00	0.00	0.00	0.01	0.04	0.24	0.11	0.46	0.17	0.03	0.00	0.00	1.06
	Mean	0.00	0.00	0.00	0.01	0.04	0.16	0.14	0.39	0.31	0.04	0.00	0.00	1.10
Woody plants	2015	0.132762944	2.684761764	5.059743325	27.36391798	35.68372916	6.579141466	0.67856616	0.059005753	0.059005753	0.162265821	0.354034518	0.044254315	78.86
	2016	0.24	4.35	24.7	37.7	13.10	1.1	0.29	0.07	0.03	0.14	0.06	0.03	81.76
	Mean	0.18	3.52	14.88	32.52	24.38	3.84	0.49	0.06	0.04	0.15	0.20	0.04	80.31
Herbaceous plants	2015			0.33928308	2.729016079	7.23	3.540345184	2.55199882	2.153709987	1.87343266	0.472046024	0.014751438		20.90
	2016		0.05560962	1.306826081	4.36	6.20	2.015848742	0.639510635	2.516335326	0.778534687	0.208536077	0.02780481		18.11
	Mean	0.00	0.03	0.82	3.55	6.71	2.78	1.60	2.34	1.33	0.34	0.02		19.51
Total	2015	0.13	2.68	5.41	30.16	42.98	10.14	3.27	2.21	1.93	0.63	0.36	0.04	100.00
	2016	0.23	4.40	26.03	42.12	19.28	3.11	0.93	2.58	0.80	0.34	0.09	0.02	100.00
	Mean	0.18	3.55	15.73	36.15	31.13	6.63	2.10	2.40	1.37	0.49	0.23	0.04	100.00

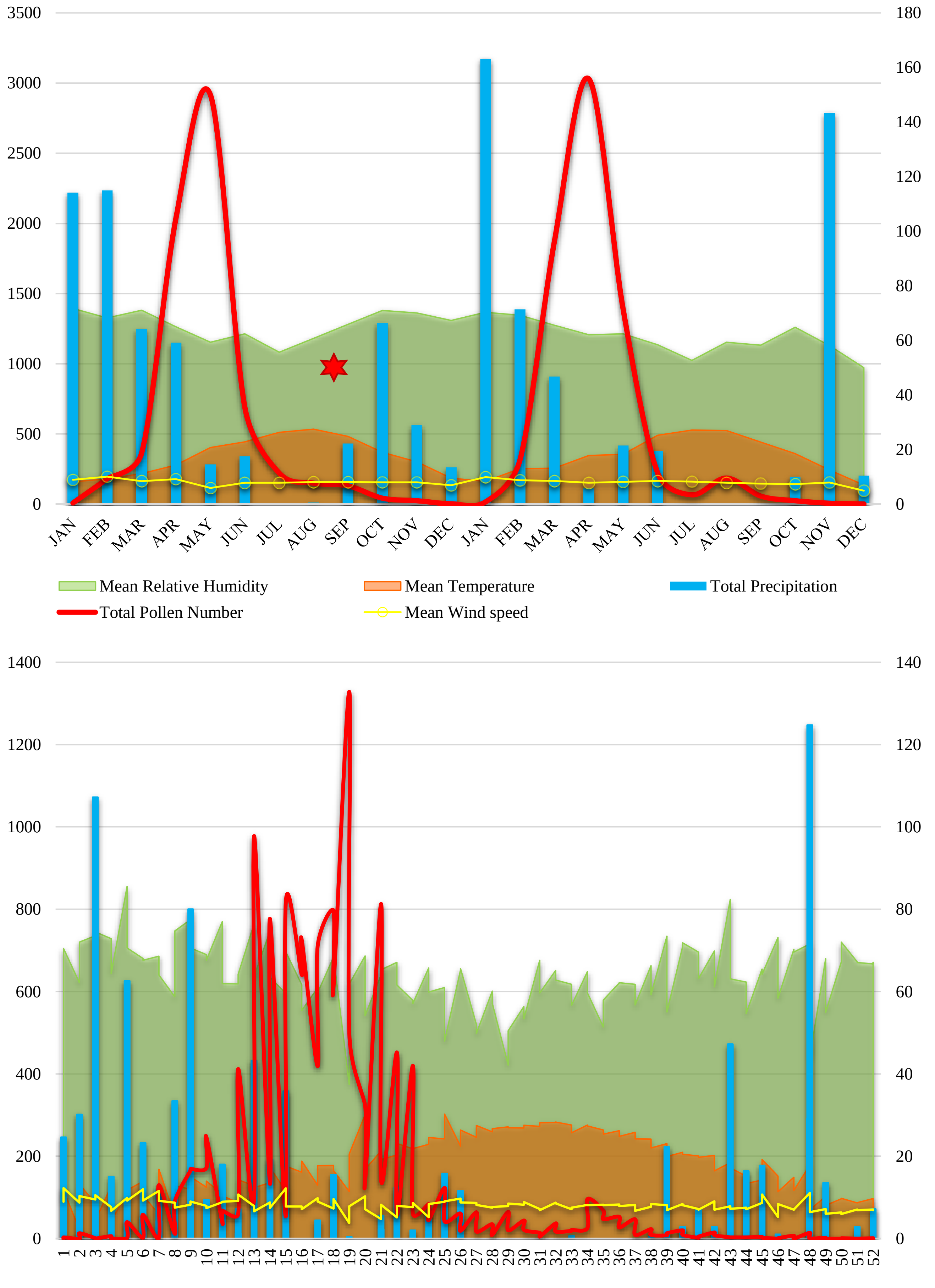

Fig. 2. Monthly and weekly variations of airborne pollen numbers (*left axis*) and meteorological parameters (*right axis*) in two consecutive years in Dikili atmosphere in the years 2015-2016.

Table 3. Correlation between weekly pollen amount and concurrent meteorological parameters of Dikili atmosphere for years 2015-2016.

		Rainfall	Relative humidity	Mean temperature	Wind speed
Woody plants	2015	-	-	-	-
	2016	-	-	0,292	-
Herbaceous plants	2015	-0,351	-0,470	-0,767	-
	2016	-	-0,288	-	0,593
Pinus	2015	-	-0,295	0,516	-
	2016	-	-	-	-
Quercus	2015	-	-	-	-
	2016	-	-	-	-
Olea europaea	2015	-	-0,378	0,500	-
	2016	-	-	0,358	-
Poaceae	2015	-0,294	-0,421	0,771	-
	2016	-	-	0,558	-
Cupressaceae/Taxaceae	2015	-	-	-0,318	-
	2016	0,482	0,388	-0,291	0,303
Fraxinus	2015	-	-	-	-
	2016	0,298	-	-	-
Ambrosia	2015	-0,279	-	0,432	-
	2016	-0,280	-0,283	0,425	-
Plantago	2015	-	-	0,388	-
	2016	-	-	0,335	-
Platanus	2015	-	-	-	-
	2016	-	-	-	-
Pistacia	2015	-	-	-	-
	2016	-	-	-	-
Amaranthaceae	2015	-0,425	-0,419	0,785	-
	2016	-0,400	-0,513	0,727	-

Correlation is significant at the 0.05 level-two-tailed

Discussion

Forty-seven types of pollen were identified in Dikili atmosphere, and pollen grains of woody plants dominated in the atmospheric spectrum with the two years mean of 80.31% (Table 1). The high dominance of pollen grains of woody plants in the air is very common in western Turkey (Bicakci *et al*., 2000; Guvensen & Ozturk, 2003; Bilisik *et al*., 2008a; Altunoglu *et al*., 2010).

The data from the two-year atmospheric sampling were considered inadequate to generate a pollen calendar, and Table 2 was prepared to show seasonal distributions of pollen in the atmosphere over the years. It is noted that in general, pollen types of woody plants were seen at maximum levels in the atmosphere between the February-May terms. In contrast, pollen types of herbaceous plants were recorded at maximum levels in the May-August term (Table 2). It was an expected result because anemophilous trees start their vegetation period earlier, but the annual herbs shed their pollen during the mid or late summer period depending on the seed development time and life cycle. It has been found that woody plants such as Cupressaceae/Taxaceae, *Fraxinus, Pinus, Quercus, Platanus, Pistacia,* and herbaceous Poaceae, *Plantago,* and Amaranthaceae are the characteristic airborne pollen types of many parts of the Mediterranean region (Altintas *et al*., 2004; Gioulekas *et al*., 2004; Gucel *et al*., 2013; Tosunoglu *et al*., 2009; Tosunoglu *et al*., 2015; Tosunoglu & Bicakci, 2015). Cupressaceae/ Taxaceae and Poaceae pollen deserve a particular emphasis because of having a very long pollen season, probably because of including many taxa and as a result of limited identification of the pollen grains. Another pollen type that needs to be emphasized is *Ambrosia* pollen. Three species of the genus *Ambrosia* are distributed in Turkey; *A. maritima* and A. *tenuifolia* are native species, but A. *artemisiifolia* is an invasive naturalized species, in North Anatolia. *Ambrosia* pollen is one of the most important aeroallergens (Thibauton *et al.*, 2004). Atmospheric *Ambrosia* has been previously reported with small amounts in many regions of Turkey; some of these are thought to have originated from indigenous species, and the possible wind transport from Europe has also been reported (Bicakci & Tosunoglu, 2015). However, the amount of atmospheric *Ambrosia* pollen in any of those aerobiology studies was not as high as in Dikili. The presence of this plant in this region has not been reported before. Still, the fact that *Ambrosia* was recorded as dominant pollen probably indicates that *Ambrosia artemisiifolia* invaded into western Anatolia.

When we look at the atmospheric pollen spectrum and the floristic structure in Dikili, both seem to be compatible with each other. Mediterranean maquis elements are dominant in the coastal part of Western Anatolia. In this regard, the prevalence of *Pinus brutia*, which reaches up to the sea and ascends up to 800 m, maybe the main reason for being the most dominant pollen. On the other hand, *Quercus*, *Fraxinus,* and *Pistacia* species, which are recorded as predominant pollen in the Dikili atmosphere, are also frequently encountered plants in the maquis of the region. Another taxon that significantly contributes to the annual pollen index is the Cupressaceae/Taxaceae family, which is the leading cause of winter pollinosis in the Mediterranean basin (Hidalgo *et al*., 2003). Pollen of these families is highly represented in the atmosphere around the Mediterranean basin both in spring and autumn due to a large amount of pollen production and expected to pose a major challenge for pollinosis (Papa *et al*., 2001; Docampo *et al*., 2007). *Olea europaea* is a very intensely cultivated plant within the Aegean basin. In the previous studies also olive pollen were reported as dominant atmospheric pollen in the region (Guvensen *et al*., 2005; Bilisik *et al*., 2008b; Guvensen *et al*., 2018). Pollen of the olive tree is considered as a great risk for pollinosis (Domínguez-Vilches *et al*., 1993; Liccardi *et al*., 1996). Another dominant pollen type belongs to the plane tree and *Platanus orientalis* is naturally distributed in the valleys or where the groundwater is high in western Anatolia also *P. occidentalis* and *P.* x *acerifolia* being used intensely in the roadside afforestation in the city. The dominance of Poaceae pollen from herbaceous plants in the atmosphere of Dikili is not surprising data because it is almost a usual situation for the whole of Turkey. Even in the eastern regions of Anatolia, Poaceae pollen were recorded in the atmosphere more intensely than the pollen of woody plants (Bicakci *et al.*, 2017, Celenk et Bicakci 2005). *Plantago* and Amaranthaceae pollen are generally represented types in Turkey atmosphere (Guvensen *et al*., 2005; Bilisik *et al*., 2008b; Kizilpinar *et al*., 2012; Bicakci *et al*., 2017), so it is seen that unexpectedly high proportion of ragweed pollen was the only unexpected result from herbaceous plants for the study area. In general, allergic pollen profiles in Dikili atmosphere suggested that all of the dominant pollen constituting more than 90% of the pollen spectrum were also reported as important aeroallergens before (D'Amato & Lobefalo, 1989; D'Amato *et al*., 1991; Keynan *et al*., 1997; Varela *et al*., 1997; Fang *et al*., 2001; Gioulekas *et al*., 2004; D'Amato *et al*., 2007; Mandal *et al*., 2008).

Allergen susceptibilities were found to be quite high in Western Anatolia region, especially for some dominated taxa. Western Anatolia region is characterized by the highest Cupressaceae/Taxaceae, Poaceae, *Quercus, Platanus,* and *Olea* pollen concentrations (Bicakci & Tosunoglu, 2019) with parallel to this study. According to data, based on skin prick tests from the region, the allergen sensitivity rates were found to be very high; Poaceae pollen sensitivity was reported as 11.30-54.00%; 32.00% for *Ambrosia*; 3.25-14.30% for *Cupressaceae*; 2.80-30.00% for *Olea* and 2.00-14.00% for *Pinus* (Bicakci & Tosunoglu, 2019). These values and the high allergic effects of dominant taxa in the studied region emphasize the allergic importance of inhabitants of the area.

From a statistical point of view; although a numerical difference was seen among some taxa between the two years, no statistical significant difference was found between the weekly amounts of total pollen of herbaceous plants, woody plants, or dominant pollen between two years ($p>0.05$). The lack of meteorological differences between the two years ($p>0.05$) supports this situation. On the other hand, it was expected to find the total amount of pollen reaching the maximum level in April and May according to years showing a positive correlation with the increase in temperature in both years.

There is a general discourse that temperature and wind increase the atmospheric pollen concentration and that humidity and rainfall reduce it (Ballero & Maxia, 2003; Rodríguez-Rajo *et al*., 2003; Ribeiro *et al*., 2003; Gioulekas *et al.,* 2004; Ščevková *et al.,* 2015). However, in the present study, contrary to previous reports and sometimes harmonious results were observed. The amount of pollen was not affected by the parameters, such as total weekly rainfall, average relative humidity, and average wind speed every two years, only significant positive correlations were observed between the weekly mean temperature and the amount of woody plant pollen in the second sampling year. In the 20th week of the year 2015, a very sudden decrease in the amount of pollen was observed. In this week, extreme temperature and humidity increase might be the reason for the decline in pollen by one forths, however, in the year 2016, no such change was recorded (Fig. 2).

The most intense pollen type in the Dikili atmosphere was *Pinus* during the years 2015-2016 (Table 1). Statistically, the amount of weekly *Pinus* pollen was positively correlated with the weekly mean temperature in 2015, and a significant negative correlation with weekly relative humidity was also recorded (Table 3). In terms of both temperature and humidity, these findings were found to be consistent with preliminary regional studies (Tosunoglu & Bicakci, 2015; Uğuz *et al*., 2018). However, there was no statistical correlation between the weekly quantities of *Pinus* pollen and any meteorological parameters for the year 2016 as well as the pollen amount of *Quercus*, *Platanus,* and *Pistacia* in both years (Table 3). The weekly amounts of *Olea europaea* pollen in the atmosphere showed a significant positive correlation with the temperature for both years, and the similar results were also reported from other studies (Tosunoglu & Bicakci, 2015; Uğuz *et al.*, 2018). The weekly quantities of Poaceae pollen and the weekly average temperature showed a significant positive correlation in both years (Table 3), while some of the studies were parallel to this (Altintas *et al*., 2004; Uğuz *et al*., 2017; Guvensen *et al*., 2018) and others reported (Çeter *et al*., 2012; Bicakci *et al*., 2017; Uğuz *et al*., 2017) exactly opposite of this. The only aeropalynological study, which was performed in Manisa in the same sampling year, reported a significant correlation between the amount of Poaceae pollen and rainfall similar to our study; (Guvensen *et al*., 2018). Poaceae pollen were reported to have the highest levels in the atmosphere in western Anatolia in the April-May term (Bicakci *et al*., 2009). The effect of excessive rainfall on Poaceae pollen in April 2015 might be attributed to the significant negative correlation between the weekly total rain amount and the average weekly amount of moisture in the first year (Fig. 2, Table 3). Also, similarly synchronous study was performed in Manisa (Guvensen *et al*., 2018) reported a significant negative correlation between *Olea europea* pollen quantities and relative humidity as well as in our study (Table 3). Significant negative correlations founded between daily Cupressaceae/ Taxaceae pollen concentrations and mean weekly temperature (Table 3), which was parallel the western coastal part of Turkey (Tosunoglu & Bicakci, 2015) and on the contrary to the eastern high-altitude part of Turkey (Bicakci *et al*., 2017). There was a negative correlation between *Fraxinus* pollen in the atmospheric weekly amount and weekly total rainfall in the first year. No investigation was conducted to study the effects of meteorological parameters on the amount of ragweed pollen levels from Turkey; because *Ambrosia* pollen was recorded for the first time in this study as a dominant pollen type as no data could be obtained before for statistical analysis. In this study, the weekly quantities of ragweed pollen were correlated positively with weekly mean temperature and negatively correlated with total precipitation in both years, and also negatively correlated with mean relative humidity in the second sampling year (Table 3). The weekly amounts of *Plantago* pollen in the atmosphere were positively correlated with weekly mean temperature in both years contrary to the report in Bodrum (Tosunoglu & Bicakci, 2015). The weekly quantities of Amaranthaceae pollen showed a significant positive correlation with weekly average temperature and significant negative correlation with weekly mean humidity and weekly total rainfall of both years (Table 3). This situation is found compatible with the general rules and also with previous studies (Bicakci *et al*., 2017; Uğuz *et al*., 2017).

In conclusion, - 6986 pollen grains over the average of sampling years belonging to 47 taxa were determined in the atmosphere of Dikili, and a number of identified woody taxa (26) were higher than herbaceous taxa (21) in this spectrum.

The atmospheric sampling data are characterized by the high presence of woody plants in spring, as well as the great presentation of herbaceous plants in late spring to early winter.

Almost all of the taxa detected dominant in this study have been reported by various authors to cause highly allergic reactions in susceptible individuals. In this respect, the April-May term can be thought of as a risky period for sensitive individuals living in or visiting the region.

The high peak of *Ambrosia* pollen and its dominance were found remarkable and can be represented as a hot-point for western Anatolia, where the presence of the plant has not been registered yet.

Acknowledgments

Many thanks to Vahide & Ali Imrak Tosunoglu for their technical support and to Hakan Tosunoglu for the statistical analysis and his contributions.

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(Received for publication 25 January 2019)