A study on airborne pollen grains in the atmosphere of Gerze (Sinop, Turkey) and their relationship with meteorological conditions

Hülya ÖZLER

Department of Biology, Faculty of Arts and Science, Sinop University, Sinop, Turkey,
e-mail: hulyaozler06@gmail.com

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Abstract. Airborne pollen grains in the atmosphere of Gerze (North Turkey) were identified between 1st January 2017 and 31st December 2018 by means of a Burkard volumetric spore trap. The effect of meteorological parameters (mean temperature, total rainfall, relative humidity, wind speed) on the amount of pollen grains was investigated. During a period of two years, a total of 1015 pollen grains was recorded, belonging to 24 taxa. The dominant arboreal pollen taxa in the atmosphere were *Cupressaceae/Taxaceae* (60.2%), *Pinaceae* (16.9%), *Alnus* sp. (8.3%), *Corylus* sp. (2.7%), *Quercus* sp. (1.8%), *Fraxinus* sp. (1.3%), *Populus* sp. (1.3%) and *Olea europaea* (1.2%), while the dominant non-arboreal pollen taxa were *Mercurialis* sp. (1.5%) and *Poaceae* (1.2%). The pollen grains captured by the trap reflected the floristic diversity of the region. Higher temperature and wind speed were observed as influencing positively the increase of pollen amount, whereas rainfall and relative humidity had a negative effect.

Key words: Airborne pollen, Gerze, meteorological conditions Turkey, volumetric method,

Introduction

Turkey is the one of the interesting and very rich countries in terms of its flora. It is situated between the Euro-Siberian, Irano-Turanian and Mediterranean floristic regions and the different ecological environments, edaphic conditions, geomorphological diversity, and altitude increase its floristic and biological diversity. Therefore, vegetation also varies, depending on the different geographical regions and climatic conditions (Malyer 2011). The pollination periods of plants in each region and the time the pollen is in the air vary from year to year. That is why, aeropalynological studies have been carried out in many countries for many years (Atkinson & Larsson 1990; González Minero & Candau 1997; Gioulekas & al. 2004; Šaulienė & Veriankaitė 2012). Long-term monitoring of airborne pollen grains contributes to a more accurate pollen forecasting and provides valuable information about the climatic changes at local and regional level (García-Mozo & al. 2002; Beggs 2004). Another important aspect is monitoring of invasive weeds such as *Ambrosia* spp., which cause allergy and spread rapidly in many European countries (D'amato & al. 2007).

Aeropalynological studies in Sinop were conducted for the first time by Ceter & al. (2014) in 2010–2012 and by Cançi Demir (2018) in 2016–2017 by using the volumetric method. This study was carried out in the years 2017–2018 in the atmosphere of Gerze, a district of Sinop. Although it is 39 km away from Sinop, Gerze has different meteorological conditions, namely wind direction, wind speed and rainfall. Earlier studies, both in Turkey (e.g. Bartın, Eskişehir, Trabzon, İstanbul, Kırşehir) and other countries (e.g. Cordoba-Spain, Lagos-Nigeria, Las Vegas-USA), have revealed that relative abundance of airborne pollen grains changes even in different parts of a city (Kaya & al.2004; Potoğlu Erkara & al. 2007; Yavru 2007; Celenk & al. 2010; Bülbül & Pehlivan 2013; Velasco-Jiménez & al. 2013; Adeniyi & al. 2018; Patel & al. 2018). This study investigated the effects of meteorological conditions on the amount of pollen grains and their annual changes in Gerze's atmosphere. Furthermore, the aim of this aeropalynological study was to determine the pollination periods of the plants in the studied area, identify the long-distance transport of pollen grains with airflows, prepare pollen calendars, and inform the sensitive individuals with pollen allergy in the region to take precautions, whenever necessary.

Material and methods

Description of study area and vegetation

The study was carried out between 1st January 2017 and 31st December 2018 in Gerze (Sinop) situated in the north of Turkey (41°48'6"N 35°11'48"E). Gerze is surrounded by the Black Sea in the north, Boyabat and Durağan in the south, Dikmen in the east, and Sinop in the west. The important elevations in the study area are the mountains Elma, Köse, Dede, and Hasan (Fig. 1). Phytogeographically, the study area is located in the Euxine province of the Euro-Siberian floristic region (Karaer & Kılınç 1993; Özen & Kılınç 1995). Euxine base taxa participate in the floristic structure of the Mediterranean enclaves. Although the main climate of the region is oceanic, the presence of the Mediterranean microclimate brings richness and diversity to the flora. The forest of coniferous and deciduous plant taxa prevail in the higher altitudes of Gerze. The dominant taxa are: *Pinus brutia* Ten., *P. sylvestris* L., *P. nigra* Arn. subsp. *pallasiana* (Lamb.) Holmboe, *Abies nordmanniana* (Stev.) Spach subsp. *bornmulleriana* (Mattf.) Coode & Cullen *Juniperus oxycedrus* L. subsp. *oxycedrus*, *J. exelca* Bieb., *Ulmus minor* Miller subsp. *minor*, *Juglans regia* L., *Fagus orientalis* Lipsky, *Quercus petraea* (Mattuschka) Liebl. subsp. *iberica* (Stevan ex Bieb.) Krassiin, *Carpinus betulus* L., *C. orientalis* Miller subsp. *orientalis, Ostrya carpinifolia* Scop., *Cerasus avium* (L.) Moech, *Rubus hirtus* Waldst. and Kit., *Sanguisorba minor* Scop. subsp. *muricata* (Spach.) Briq., *Crataegus orientalis* Pallas ex Bieb. var. *orientalis*, *Myrtus communis* L. subsp. *communis*, *Hedera helix* L., *Cornus songuineae* L. subsp. *australis* (C.A. Meyer) Jav., *C. mas* L., *Laurus nobilis* L., *Olea europaea* L. var. *europaea* Zhukovsky, and *Corylus maxima* Miller. The common herbaceous and climber taxa in the study area and its environments are composed of *Ephedra major* Host, *Helleborus orientalis* Lam, *Consolida orientalis* (Gay) Shröd., *Clematis vitalba* L., *Adonis annua* L., *A. aestivalis* L. subsp. *aestivalis*, *Ranunculus brutius* Ten., *R. neapolitanus* Ten., *Thalictrum minus* L. var. *majus* (Crantz) Crepin, *Berberis vulgaris* L., *B. crataegina* DC., *Epimedium pubigenum* (DC.) Maren and Decaisne, *Papaver hybridum* L., *Cotinus cogggyria* Scop., *Rhus coriaria* L., *Chamaecystisus austriaeus* (L.) Link, *Angyrolobium bieberstenii* Ball, *Vicia crocea* (Desf.) Fedtsch. *V. villosa* Roth subsp. *villosa*, *Lathyrus digitatus* (Bieb.) Fiori, *L. nissolia* L., *Ononis viscosa* L. subsp. *breviflora* (DC.) Nyman, *Trifolium pretense* L. var. *pretense*, *T. medium* L. var. *medium*, *T. canascens* Willd., *Medicago orbicularis* (L.) Bart., *Lotus angustissimus* L., *Hymenocarpus circinnatus* (L.) Savi, *Sambucus ebulus* L., *Scabiosa columbaria* L., *Solanum dulcamara* L., *Verbascum spectabile* Bieb. var. *spectabile*, *Lamium purpureum* L. var. *purpureum*, *Stachys byzantine* C. Koch, *Salvia forskahlei* L., *Plantago lanceolata* L., *Daphne*

Fig. 1. A map of Gerze (Sinop) survey area.

pontica L., *Laurus nobilis* L., *Viscum album* L. subsp. *abietis* (Wiesb.) Abromeit, *Euphorbia heliocopia* L., *Parietaria judaica* L., *Ficus carica* L., subsp. *carica*, *Galium rotundifolium* L., *G. humifusum* Bieb., *Smilax excelca* L., *Ruscus aculeatus* L. var. *aculeatus*, *Ornithogalum narborense* L., *Muscari neglectum* Guss., *Fritillaria pontica* Wahlenb., *Crocus specious* Bieb. subsp. *xantholaimos* Mathew, *Juncus effuses* L., *Carex sylvatica* Hudson subsp. *sylvatica*, *Festuca arundinacea* Schreber subsp. *arundinacea*, *Poa annua* L., *P. paratensis* L., *P. bulbosa* L., *Glyceria plicata* (Fries) Fries, *Paspalum paspalodes* (Michx.) Schribrer. (Özen & Kılınç 1995). *Washingtonia robusta* H. Wendl., *Tilia spp., Acer negundo* L., *Populus spp., Cupressus spp., Cercis siliquastrum* L., *Prunus laurocerasus* L., *Prunus ceracifera* Ehrh. , *Prunus serrulata* L., *Robinia pseudoacacia* L., *Buxus sempervirens* L., *Callistemon viminalis* (Sol. ex Gaertner) G.Don ex Loudon, *Cotoneaster dammeri* (Schneid), *Lagerstroemia indica* L., *Catalpa bignonioides* Walter, *Cedrus atlantica* Manetti, *Liquidambar orientalis* Mill., and there are naturally distributed plants such as *Pinus sylvestris* L. and *Olea europaea L.* used as ornamentals in the parks and gardens in Gerze.

Pollen collection

A Burkard volumetric 7-day spore trap (Burkard Manufacturing Co. Ltd., the United Kingdom) was used for pollen sampling. According to the recommendations by the Spanish Aerobiological Network (REA: Red Española de Aerobiología, Gala´n & al. 2017), the sampler was placed on the roof of a building in the center of Gerze, at approximately 17 m above the ground level. The device was located at an altitude of 36 m a.s.l. and at 41°48'10.06"N, 35°11'55"E.

Airborne pollen grains stuck to adhesive-coated Melinex tape (Burkard gelvatol) on the disc in the Burkard trap. The Melinex tape was cut into seven equal sections, each section representing a 24-hour period (viz. 48 mm). The tape sections were mounted on microscope slides and stained with glycerine jelly including safranine. The counting of pollen grains was performed with a Leica microscope at magnification ×40 and ×100, using a single longitudinal traverse. Pollen concentrations were converted to mean daily concentrations (pollen grains/m^3). Reference slides of local pollen flora and palynological atlases (Hyde & Adams 1958; Aytug 1971; Nilsson & al. 1977; Bassett & al. 1978; Knox 1979; Lewis & al. 1983; Pehlivan 1995; Kapp & al. 2000) were used for identification of the pollen grains. The main pollen season (TPS) was determined by the 98 % method described by Emberlin & al. (1993) and Jato & al. (2006). The terminology was based on Galán & al. (2017).

Statistical analysis

In order to find correlation between the effect of meteorological factors (mean daily temperature, mean relative humidity, total precipitation, and mean wind speed) and the daily average amount of the 10 dominant pollen taxa in the atmosphere of Gerze for a two-year period, Spearman's correlation analysis was used. This test was applied to the pollen grains of *Alnus* sp., Cupressaceae/Taxaceae, *Corylus* sp., *Fraxinus* sp., *Mercurialis* sp., *Olea europae*, Pinaceae, Poaceae, and *Populus* sp. determined as the dominant taxa in the atmosphere of Gerze (Table 1). An IBM SPSS version 21.0® software was used in the statistical analyses (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp. Armonk).

Table 1. The results of Spearman's correlation analysis between daily pollen count of 10 dominant taxa and the meteorological parameters of Gerze.

Dominant Pollen / Taxa	Mean Daily Temperature	Mean Total Rainfall	Mean Daily Humidity	Mean Daily Wind Speed
***Alnus* sp.**	.788**	.035	.748**	.684**
***Corylus* sp.**	.867**	.019	.632**	.731**
Cupressaceae/Taxaceae	.541**	.046	.518**	.370**
***Fraxinus* sp.**	.320	-.089	.356	.508**
***Mercurialis* sp.**	.046	.244	.370*	.490**
Olea europaea	-.008	.255	.052	.379
Pinaceae	.128	-.208	-.077	.216
Poaceae	.102	-.063	-.020	.134
***Populus* sp.**	.421*	-.057	.281	.426*
***Quercus* sp.**	-.386**	-.215	.194	.290

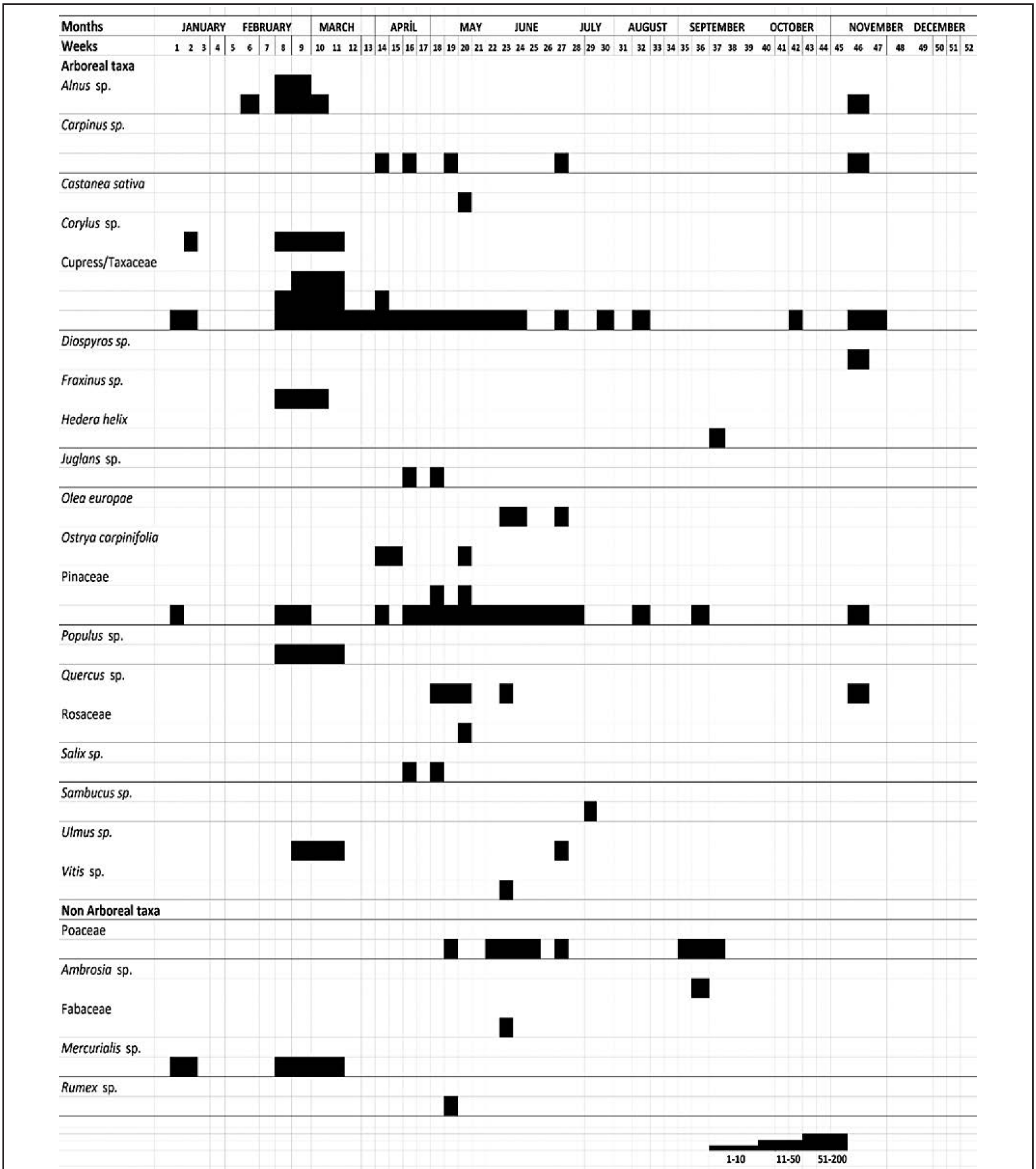
*Correlation is significant at the 0.05

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

Results

In the course of two years, a total of 1015 pollen grains belonging to 24 plant taxa were collected in the atmosphere of Gerze. Of these taxa, 19 were arboreal, and five were non-arboreal taxa. Of the 97 % of detected airborne pollen grains, 3 % belonged to arboreal taxa and non-arboreal taxa, respectively. According to the average values for the two years, the maximum pollen density was recorded in March with 52.25 %, and the minimum was recorded in October with 0.20 %. No pollen grains were recorded in December (Table 3).

Table 3. Pollen calendar of Gerze.



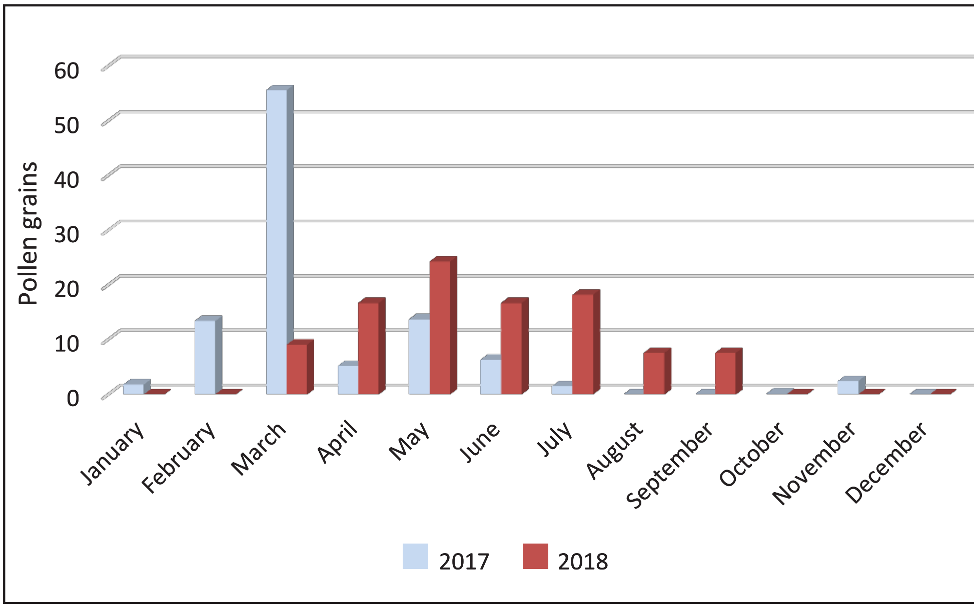


Fig. 3. Monthly variation of the average number of pollen grains.

In the first year of study, the maximum pollen concentration was observed in March (55.60 %) and the minimum pollen concentration was observed in October (0.11 %). In the second year, the highest pollen concentration was recorded in May (24.24 %). The pollen concentration was very low in March, August and September (Fig. 3).

On the basis of the average density levels of all pollen grains collected in the course of two years, the dominant arboreal taxa (≥1 %) were *Cupressaceae/Taxaceae* (60.2 %), *Pinaceae* (16.9 %), *Alnus* sp. (8.3 %), *Corylus* sp. (2.7 %), *Quercus* sp. (1.8 %), *Fraxinus* sp. (1.3 %), *Populus* sp. (1.3 %) and *Olea europaea* (1.2 %), while the non-arboreal taxa were *Mercurialis* sp. (1.5 %) and *Poaceae* (grasses) (1.2 %) (Table 2).

The impact of meteorological factors on the daily pollen concentration in the main pollen season of taxa has had different effect on different taxa. For instance, the mean daily temperature was positively correlated with the pollen of *Alnus*, *Corylus*, Cupressaceae/Taxaceae, and negatively correlated only with the pollen of *Quercus*. Generally, a positive correlation was found between the daily wind speed and the pollen grains (Table 1).

To find out the effects of meteorological factors on pollen concentration, data on meteorological parameters (mean daily temperature, relative humidity, precipitation, and wind speed) were obtained from the Ministry of Agriculture and Forestry, Sinop Meteorological Station for the years of observation (Fig. 2). In both years, the highest temperature was measured in August, and the lowest in January. In 2018, the total amount of precipitation was higher than in the previous year. Similarly, the mean relative humidity in 2018, especially for the periods of January to March and September to December, was higher than in 2017. The mean wind speed was the highest in January 2017 and in December and March 2018.

Table 2. **Annual pollen concentration and percentage of pollen taxa detected of Gerze in 2017 and 2018.**

Taxa	2017	2018	Total pollen	%
Arboreal taxa	**930**	**55**	**985**	**97,0**
Alnus sp.	84		84	8,3
Carpinus sp.	6	1	7	0,7
Castanea sativa		2	2	0,2
Corylus sp.	27		27	2,7
Cupress/Taxaceae	603	8	611	60,2
Diospyros sp.	1		1	0,1
Fraxinus sp.	13		13	1,3
Hedera helix		1	1	0,1
Juglans sp.	3		3	0,3
Olea europae	12		12	1,2
Ostrya carpinifolia	3	1	4	0,4
Pinaceae	138	34	172	16,9
Populus sp.	13		13	1,3
Quercus sp.	18		18	1,8
Rosaceae	3		3	0,3
Salix sp.	3		3	0,3
Sambucus sp.		6	6	0,6
Ulmus sp.	3	1	4	0,4
Vitis sp.		1	1	0,1
Non-arboreal taxa	**19**	**11**	**30**	**3,0**
Poaceae	5	7	12	1,2
Ambrosia sp.		1	1	0,1
Fabaceae		1	1	0,1
Mercurialis sp.	13	2	15	1,5
Rumex sp.	1		1	0,1

Fig. 2. Seasonal variation of meteorological parameters (mean temperature, total rainfall, mean relative humidity, mean wind speed, and wind rose diagram) in Gerze.

Discussion

The results of this study have shown that most dominant pollen grains in the atmosphere of Gerze belonged to the natural flora of Gerze and Sinop province, and to such plant taxa as *Olea europaea* and *Corylus* sp. grown in gardens (Kılınç & al. 1992; Özen & Kılınç 1995; Karaer & Kılınç 1993; Kılınç & Karaer 1995). The findings of the present study were compared with earlier surveys done in Sinop (Çeter & al. 2014; Canşı Demir 2018) and with other studies conducted in the Black Sea Region of Turkey (Kaya & Aras 2004; Yavru 2007; Çeter & al. 2012, 2014; Serbest & Kaplan 2014; Alan & Kaplan 2018, Türkmen & al. 2018). A total of 1015 pollen grains belonging to 24 plant taxa were recorded during the study period. Most pollen grains in the air belonged to arboreal pollen (97 %) (such as *Cupressaceae/Taxaceae, Pinaceae*, *Alnus* sp.). There was recorded 3 % ratio of non-arboreal pollen. Pollen grains of *Poaceae* belonging to the non-arboreal taxa claimed 1.2 % (Table 2). In the second year of study, there was a decrease in the number of arboreal pollen grains, and an increase in the number of non-arboreal pollen grains, as compared to the first year. In the first aeropalynological study performed between 2010 and 2012 by Çeter & al (2014) in Sinop, a total of 93 414 pollen grains belonging to 61 taxa were detected. According to their results, 69.5 % of these pollen grains were arboreal, 17.1 % were from *Poaceae* (grasses belong also to non-arboreal taxa), and 13.4 % were from non-arboreal taxa. In a later study conducted by Canşı Demir (2018) in the province of Sinop in the years 2016 and 2017, 119 361 pollen grains belonging to a total of 87 taxa were identified, including 49 arboreal taxa (71.12 %), 37 non-arboreal taxa, and 5.29 % belonging to *Poaceae*. The reason for the different number of taxa and the amount of pollen grains detected in these and earlier studies (Rodríquez-dela Cruz & al. 2010; Acar & al. 2017) may be due to changes in the meteorological factors (mean temperature, total precipitation, mean relative humidity, and mean wind speed) of the studied periods and the location and altitude of the pollen traps. Higher temperature, longer sunshine and moderate winds increase the amount of pollen in the atmosphere, while light breezes and high wind speed, precipitation and relative humidity have a negative effect on pollen concentration. Rains cause pollen to fall to the ground without spreading into the air (Gemici 2011).

In the atmosphere of Gerze, the measured wind speed in 2017 was higher than in 2018, while the temperature was slightly lower in 2017. Precipitation and relative humidity were higher in 2018. While in 2017 the wind was coming from the west (W), in 2018 it was coming from the west-southwest (WSW) (Fig. 2). The amount of rainfall and relative humidity in 2018 were quite high as compared to 2017 in the flowering seasons of the arboreal taxa, which might be the reason why the amount of pollen in the atmosphere was quite low or even non-existent in the period from January to May in 2018. Altitude differences may also affect the varying amount of pollen. Lehtimäki & al. (1991) proved that the amounts of pollen on the ground floor were higher than at the height of 15 m, while the arboreal pollen grains showed even distribution on both the ground floor and at a high level. Similarly, Chakraborty & al. (2001) have found that the quantity of herbaceous pollen grains was high at lower altitude in an agricultural farm in West Bengal.

The airborne pollen of *Cupressaceae/Taxaceae*, which is overwhelming among the dominant plant taxa, constituted 60.2 % of all pollen grains (Table 2). Evidently, that result was higher than the results obtained from central Sinop, some other localities in the Black Sea region and in other countries (Canşı Demir 2018; Alan & Kaplan 2018; Çeter & al. 2012; Çelenk & al. 2016; Camacho 2015; Greeen & al. 2002). Members of *Cupressaceae* are widely cultivated in parks and cemeteries. The highest number of pollen grains of *Cupressaceae* / *Taxaceae* was recorded in February and March, and it peaked in the 11th week (Fig. 4). The main pollen season was between 25th February and 20th June (116 days), and it was a very long pollination season. The pollen grains of this family were reported with medium-level allergenic effects (Grant-Smith 1990; D'Amato & al. 2007; Gioulekas & al. 2004; Caimmi & al. 2012). Bıçakçı & al. (2010) noted that airborne pollen grains of *Cupressaceae* / *Taxaceae* in all regions of Turkey are the most common.

In the atmosphere, the pollen grains of the taxa of *Pinaceae* (*Pinus* spp., *Abies nordmanniana*), grown and naturally distributed in the region and used as ornamentals in parks and gardens in Gerze, constituted 16.9 % of all detected pollen taxa and rated 2nd among the dominant taxa (Table 2). The main pollination season was between 2nd April and 20th June (80 days). Pollen grains of these taxa were observed most intensely in the atmosphere in May and peaked in the 18th and 20th weeks (Fig. 4). The members of *Pinaceae* have pollen grains with low allergenic effect (Pehlivan 1995). According to Bıçakçı & al. (2011), the highest rates of airborne pollen grains of *Pinaceae* and *Pinus* spp. were recorded in 42 of 59 cities in Turkey. Pollen grains of *Pinaceae* in the atmosphere in Sinop amounted to 15.48 % (Canşı Demir 2018), in Düzce to 23.69 % (Serbest & Kaplan 2014), in Kastamonu to 42.84 % (Çeter & al. 2012), and in Karabük to 47.38 % (Kaplan & Özdoğan 2015). In other countries, these pollen grains were recorded at lower rates. Nikolaidis & al. (2015) have found 5.9 % of *Pinaceae* pollen in the Alexandroupolis region in Greece. Ščevková & al. (2010) have found 6.28 % of pollen grains of *Pinaceae* in Bratislava (Slovakia).

Pollen grains of *Alnus* sp. were recorded only in 2017. These pollen grains rated 3rd and constituted 8.3 % of the pollen grains in the atmosphere of Gerze (Table 2). This result was higher as compared to central Sinop and different cities in the same geographical region (Canşı Demir 2018; Alan & Kaplan 2018; Ayvaz & al. 2008; Çeter & al. 2012; Türkmen & al. 2018). The pollen grains of *Alnus* sp. were trapped at a lower rate in the atmosphere of Bratislava (3.76 %) than in Gerze (Ščevková & al. 2010). Their numbers were the highest in February and March. They reached their maximum in the 8th week (Fig. 4). The main pollination season was between 25th February and 9th March (13 days). *Alnus* pollen is known as one of the most important allergens in Europe (Spieksma & al. 1990; Pınar 2016).

Airborne pollen grains of *Corylus* sp. rated 4th in the atmosphere of Gerze (2.7 %) and were found only in 2017, as the *Alnus* pollen grains (Table 2). This result was slightly higher than in the center of Sinop, but lower than in the atmosphere of Bartin in the Black Sea region (Canşı Demir 2018; Kaya & Aras 2004). The main pollination season was between 25th February and 10th March (14 days). The high-

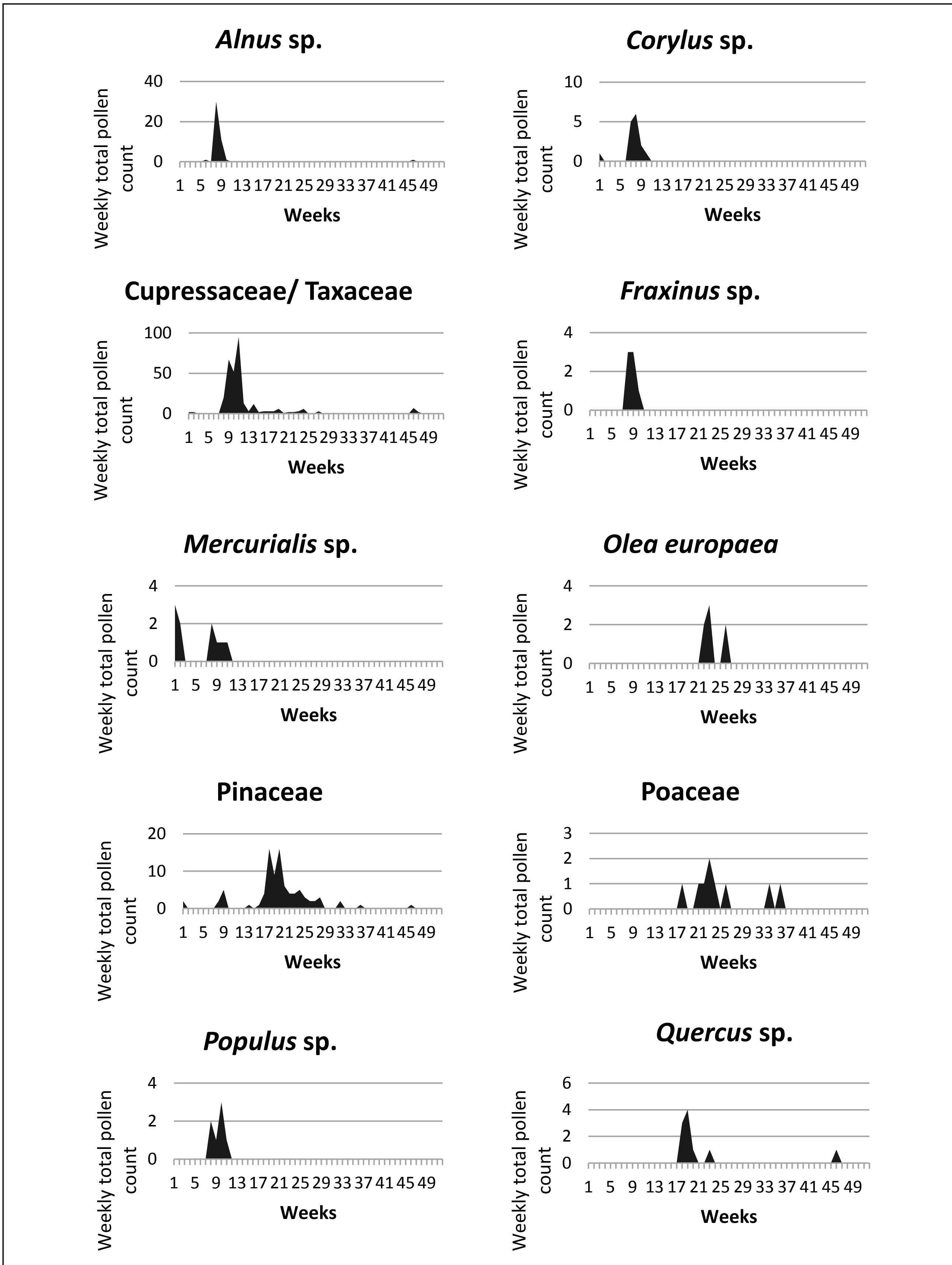


Fig. 4. Weekly total pollen concentration of 10 dominant taxa in the atmosphere of Gerze.

est pollen concentrations were observed in the 8^{th} and 9^{th} weeks (Fig. 4). The authors pointed out that the members of *Betulaceae* (e.g. *Betula*, *Alnus*, *Carpinus*), which also contains *Corylus,* produce highly allergenic pollen grains (Pehlivan 1995; Pınar 2016; D'Amato & Lobefalo 1989; Alan & al. 2010; Gioulekas & al. 2004).

Pollen grains of the *Quercus* sp. rated 5^{th} (1.8 %) in the atmosphere of Gerze and were recorded only in 2017 (Table 2). The ratio of these pollen grains was lower than in the atmospheres of Karabük (5.97 %), Kastamonu (5.51 %), Gümüşhane (7.5 %) and central Sinop (3.16 %) (Kaplan & Özdoğan 2015; Çeter & al. 2012; Türkmen & al. 2018; Canşı Demir 2018). In comparison to other countries, the *Quercus* pollen grains were higher in concentration in the air of Madrid (17 %), Ivani Zagc Grad (4.7 %), Somobor (4.1 %) and Zagreb (4.9 %) than the recorded in this study (Subiza & al. 1995; Peternel & al. 2005). The main pollen season for this pollen taxon was between 2^{nd} May and 9^{th} June (40 days). The highest density of these pollen grains was observed in May. The number of pollen grains was found to be a little bit higher in the 19^{th} week (Fig. 4). The *Quercus* pollen grains have a medium-level allergic effect (Levetin & Buck 1980; Spieksma & al. 1990; Rica & Torres 2001; Egger & al. 2008).

The pollen grains of *Mercurialis* sp. were recorded from January to March in the first year of study, while in the second year they were observed only in March. These pollen grains rated 6^{th} (1.5 %) among the dominant taxa in the air (Table 2). The pollen of *Mercurialis* sp. amounted to 2 % in the atmosphere of Sinop (2.06 %) according to Canşı Demir (2018). Çelenk & al. (2016) maintained that the percentage of pollen grains of this genus was lower than the one recorded in this study in the atmosphere of Kocaeli (İzmit) (0.07 %). The main pollination season was from 25^{th} February to 18^{th} March (22 days). The *Mercurialis* sp. pollen grains in the atmosphere of Gerze showed continuity between the 8^{th} and 11^{th} weeks, and were not observed in the atmosphere after the 11th week (Fig. 4, Table 3). The pollen grains of *M. annua* and *M. perennis* reportedly cause allergy (Pehlivan 1995; Garcia Ortega & al.,1992; Vallverdu' & al. 1998).

The airborne pollen grains of *Fraxinus* sp. and *Populus* sp. registered the same percentage (1.3 %) of all pollen grains and rated 7^{th} among the dominant pollen taxa in the atmosphere (Table 2). The main pollen season was between 25^{th} February and 10^{th} March (14 days) for the pollen grains of *Fraxinus* sp., which were detected only in February and March (8^{th} – 10^{th} weeks) in 2017 (Fig. 4, Table 3). The main pollen season for *Populus* sp. was between 25^{th} February and 19^{th} March (23 days). The percentage of *Fraxinus* sp. pollen grains was compatible with the results in Canşı Demir's (2018) study (1.33 %). However, the *Populus* sp. pollen was slightly higher than in the atmosphere of Sinop (0.22 %) (Canşı Demir 2018). Bıçakçı & al. (2014) reported that airborne pollen grains of *Populus* sp. were found in low percentage in many studies carried out in Turkey. In many studies, the *Fraxinus* sp. and *Populus* sp. pollen grains have been found to cause allergic reactions (Liccardi & al. 1995; Hemmer & al. 2000; Barderas & al. 2000; Gioulekas & al. 2004).

Pollen grains of *Olea europaea,* which is garden-grown in Gerze and Sinop and is an important aeroallergen, were found only in June and July (23^{rd}, 24^{th} and 27^{th} weeks) in 2017 (Fig. 4) (Pehlivan 1995; Pınar 2016; D'Amato & al. 2007). The pollen grains of this taxon constituted 1.2 % of all pollen grains (Table 2). This result was consistent with the percentage found in the atmosphere of Sinop (1.05 %) (Canşı Demir 2018). The main pollen season was between 11^{th} June and 7^{th} July (28 days). The percentage of found *Olea* pollen was higher in İstanbul (European part) (44 %) and Gemlik (18.19 %) than in this study (Saatçioğlu & al. 2011; Celenk & al. 2010).

Poaceae, which produces rather allergenic pollen, is among the most common taxa in the flora of Turkey and its pollen claims 1.2 % of all pollen grains detected in the atmosphere of Gerze (Table 2). This percentage is lower than that in the atmosphere of Sinop (5.29 %) (Canşı Demir 2018). The maximum pollen concentration of this taxon was observed in June (Fig. 4). The main pollen season was between 14^{th} May and 4^{th} July (52 days). The pollen grains of *Poaceae* were observed continuously in the atmosphere in the 22^{nd} and 25^{th} weeks (Fig. 4).

The result of Spearman's correlation analysis revealed that there was a significant positive correlation between the daily average amounts of *Alnus* sp., *Corylus* sp., *Cupresssaceae/Taxaceae* (99 % probability), and *Populus* sp. (95 % probability) pollen grains and daily mean temperature. There was a significant negative correlation though with the daily average amount of *Quercus* sp. pollen (99 % probability). A negative correlation was noted between the total precipitation and daily average amount of *Fraxinus* sp., *Pinaceae, Poaceae*, *Populus* sp. *Quercus* sp. pollen grains. There was a significant positive correlation between the mean wind speed and the amount of *Alnus* sp., *Corylus* sp., *Cupresssaceae/Taxaceae*, *Fraxinus* sp., *Mercurialis* sp. (99 % probability), and *Populus* sp. (95 %) pollen grains. There was no positive or negative correlation between the meteorological factors and the amount of *Olea europaea*, *Pinaceae* and *Poaceae* pollen grains in the atmosphere of Gerze in the two-year period of study (Table 1).

Conclusions

Daily, weekly and monthly changes of airborne pollen grains were investigated in this study, and a weekly pollen calendar was prepared by taking the average value for each year for Gerze (Table 3). The maximum pollen concentrations were observed in March and May. The airborne pollen grains of 24 taxa were determined in 2017 and 2018. Ten dominant pollen taxa (*Cupressaceae/Taxaceae, Pinaceae*, *Alnus* sp., *Corylus* sp., *Quercus* sp., *Fraxinus* sp., *Populus* sp., *Olea europaea*, *Mercurialis* sp. and *Poaceae*) were detected in the atmosphere. The identified pollen taxa represented the vegetation of Gerze and the province of Sinop. The pollen of *Ambrosia* which is highly allergenic (Smith & al. 2013; Celenk & Malyer 2017), besides being an invasive weed, was not among the dominant pollen grains in this study. However, it seems inevitable that it would become an important environmental and health-related problem in the future. According to the results of this study, the pollen calendar that was prepared will help physicians in the diagnosis and treatment of allergic diseases, and will provide information about the vegetation in the region. Long-term aeropalynological studies seem quite appropriate for the purpose of monitoring such hazardous plants like *Ambrosia*, climatic changes and estimated models for Gerze and Sinop.

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