

Analysis of airborne pollen grains in Bilecik, Turkey

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Received: 20 June 2007 / Accepted: 27 February 2008 / Published online: 23 April 2008
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Abstract In this study, pollen grains in the atmosphere of Bilecik were studied for a continuous period of 2 years (2005 and 2006) by using Durham sampler. During this period, pollen grains belonging to 46 taxa were recorded, 26 of which belonged to arboreal plants and 20 to non-arboreal. Of total 14,269 pollen grains determined in Bilecik atmosphere, 6,675 were recorded in 2005 and 7,594 were in 2006. From these, 75.74% were arboreal, 21.80% were non-arboreal and 2.47% unidentifiable. *Pinus* sp., Poaceae, Cupressaceae, *Platanus* sp., *Quercus* sp., *Salix* sp., *Ailanthus* sp., *Fagus* sp., Urticaceae, Chenopodiaceae/Amaranthaceae were the main pollen producers in the atmosphere of Bilecik, respectively. Pollen concentrations reached their highest levels in May. Atmospheric pollen concentrations in February, March, September, October and November were less than those in other months.

Keywords Aeropalynology · Bilecik · Ecology · Pollen calendar · Turkey

Introduction

Atmosphere concentration of different pollen types varies enormously from one country to another, in regions of the same country, and even among different cities, because pollen emissions depend on vegetation and environmental conditions (Ribeiro et al. 2003). A pollen calendar of a particular area is, therefore, becoming more important for allergological and ecological uses (Badya and Pasha 1991; Mullins and Emberlin 1997; Docampo et al. 2007). The fact that pollen grains of some plants are allergens for humans and can cause some respiratory system diseases is now well known. These diseases appear especially during the flowering periods of plants. Determination of the type and concentration of pollen grains will be beneficial for patients suffering from allergic diseases (Mandrioli et al. 1982; D'Amato et al. 1983; Bousquet et al. 1984; Bousquet et al. 1986; Spieksma et al. 1989; D'Amato et al. 1998; Sin et al. 2001; D'Amato and Liccardi 2003; Türe and Şalkurt 2005; Bıçakçı et al. 2005; Bıçakçı 2006; Erkara 2007).

The main purpose of the study is to determine airborne pollen grains in the atmosphere of Bilecik, their percentage values, pollen releasing periods and to present pollen calendar of Bilecik based on the results of 2-year (2005–2006) continuous gravimetric sampling.

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Materials and methods

Bilecik is a city in northwestern Turkey with nearly 200,000 inhabitants. It is situated at 40°09' N, 29°59' E and at an altitude of 526 m (Fig. 1).

When meteorological data belonging to Bilecik Meteorology Station is evaluated, it can be seen that dry period in Bilecik is between the end of fifth month and ninth month. Annual mean temperature is 12.3°C and annual mean precipitation is 436.4 mm for the region (Türe and Böcük 2000).

The study area is located at the intersection of three phytogeographical regions (Irano-Turanian, Euro-Siberian, Mediterranean). Most common trees and shrubs in the region are: *Pinus nigra*, *Fagus orientalis*, *Carpinus betulus*, *Quercus pubescens* and *Juniperus oxycedrus*. In rural areas, major weeds and grasses

belong to Poaceae, Lamiaceae, Fabaceae, Asteraceae and Brassicaceae. Some kinds of cereals (wheat, barley, rye, oats, corn etc.), pulses (chickpea, bean etc.), some industrial plants (patato, sugar beet, sunflower etc.), some vegetable and fruits, common hops (*Humulus lupulus* L.) are also cultivated in different parts of the province (Türe and Tokur, 2000). Some species like *Pinus nigra*, *Cedrus libani*, *Populus* sp., *Acer* sp., *Tilia* sp., *Alnus* sp., *Fraxinus* sp., *Robinia* sp., *Salix* sp. are frequently grown in the parks, gardens and streets of Bilecik.

In this study, airborne pollen grains in Bilecik atmosphere were studied by using gravimetric method and Durham sampler during two consecutive years (2005–2006). The Durham sampler was placed on roof of a 10 m height building above ground level. Position of the sampler allowed air movement from all sides.

Fig. 1 Location map of Bilecik province

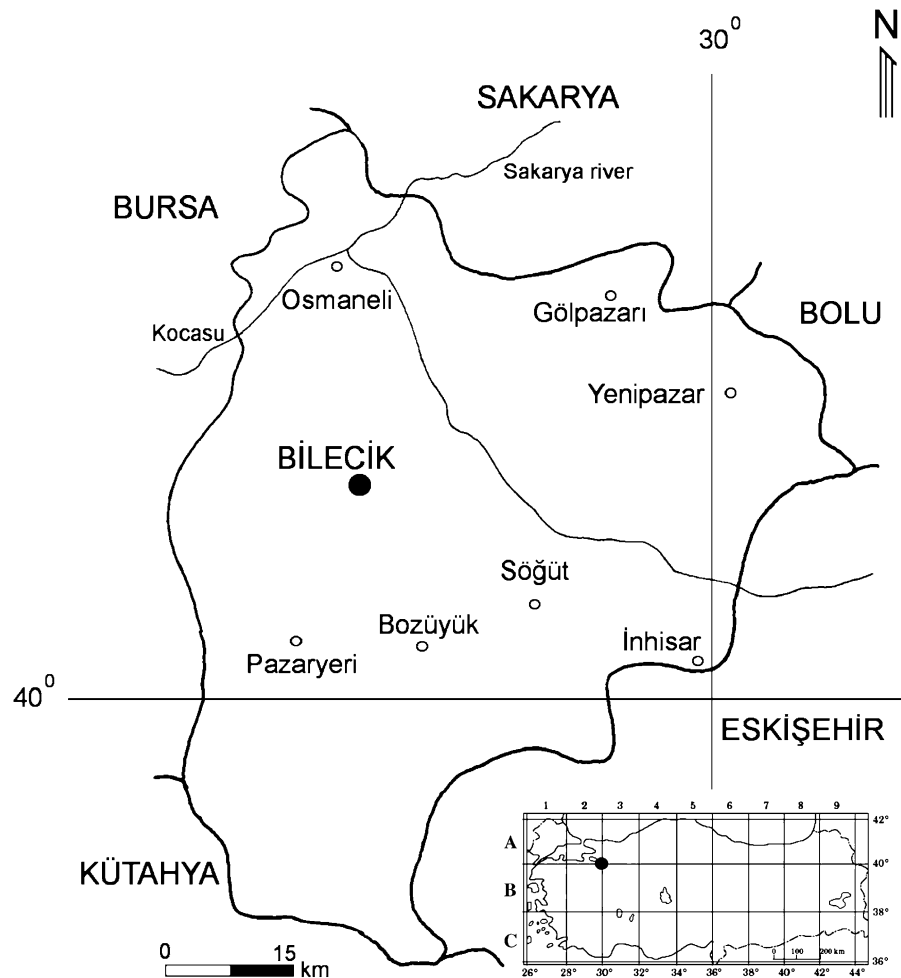


Table 1 Annual total of weekly pollen counts

	2005	2006	Total	Percent
Arboreal plants				
<i>Acer</i>	65	54	119	0.83
<i>Aesculus</i>	48	27	75	0.53
<i>Ailanthus</i>	148	159	307	2.15
<i>Alnus</i>	34	52	86	0.60
<i>Betula</i>	12	8	20	0.14
<i>Carpinus</i>	56	78	134	0.94
<i>Castanea</i>	42	65	107	0.75
<i>Cedrus</i>	96	72	168	1.18
<i>Coryllus</i>	41	32	73	0.51
Cupressaceae	764	997	1,761	12.34
Ericaceae	41	28	69	0.48
<i>Fagus</i>	173	124	297	2.08
<i>Fraxinus</i>	32	67	99	0.69
<i>Juglans</i>	79	54	133	0.93
<i>Ligustrum</i>	5	8	13	0.09
Moraceae	98	107	205	1.44
Oleaceae	13	24	37	0.26
<i>Pinus</i>	1,643	1,972	3,615	25.33
<i>Platanus</i>	837	743	1,580	11.07
<i>Populus</i>	27	49	76	0.53
<i>Quercus</i>	582	655	1,237	8.67
<i>Robinia</i>	29	58	87	0.61
Rosaceae	78	74	152	1.07
<i>Salix</i>	167	143	310	2.17
<i>Tilia</i>	13	8	21	0.15
<i>Ulmus</i>	9	17	26	0.18
Total grains of arboreal plants	5,132	5,675	10,807	75.74
Non-arboreal plants				
Apiaceae	19	37	56	0.39
Asteraceae	63	82	145	1.02
Brassicaceae	10	17	27	0.19
Caryophyllaceae	12	7	19	0.13
<i>Centaurea</i>	8	23	31	0.22
Chenopodiaceae/Amaranthaceae	116	141	257	1.80
Cyperaceae	24	9	33	0.23
Juncaceae	1	3	4	0.03
Labiatae	10	4	14	0.10
Leguminosae	7	9	16	0.11
Malvaceae	1	1	2	0.01
Papaveraceae	2	7	9	0.06
<i>Plantago</i>	54	76	130	0.91
Poaceae	873	1,018	1,891	13.25
Ranunculaceae	6	2	8	0.06
Rubiaceae	11	13	24	0.17
<i>Rumex</i>	38	53	91	0.64
<i>Typha</i>	2	1	3	0.02
Urticaceae	98	164	262	1.84
<i>Xanthium</i>	37	51	88	0.62
Total grains from non-arboreal plants	1,392	1,718	3,110	21.80
Unidentified	151	201	352	2.47
Total pollen number	6,675	7,594	14,269	100.00

Before exposure, slides were covered with glycerine jelly mixed with basic fuchsin (Charpin and Surinyach 1974). Slides were changed weekly. Pollen counts were made once a week, and total weekly counts were converted to the number of pollen grains per cm². Identification of pollen grains were made at least up to family or genus levels. Grains which could not be identified were considered as unidentified types.

Results

A total of 14,269 pollen grains belonging to 46 taxa were identified and recorded in Bilecik. Twenty-six of which belonged to arboreal plants and 20 to non arboreal. Of these, 6,675 were identified in 2005 and 7,594 in 2006. Of total pollen grains in Bilecik's environment, 75.74% was found to be arboreal, 21.80% was non-arboreal. 2.47% of the total pollens were unidentified (Table 1).

The major pollen producers in the atmosphere of Bilecik were arboreal plants such as *Pinus* sp. (25.33%), Cupressaceae (12.34%), *Platanus* sp. (11.07%), *Quercus* sp. (8.67%), *Salix* sp. (2.17%), *Ailanthus* sp. (2.15%), *Fagus* sp. (2.08%), Moraceae (1.44%), *Cedrus* sp. (1.18%) and Rosaceae (1.07%). They accounted for 67.5% of the total pollen grains. Among non-arboreal plants, pollen grains belonging to Poaceae (13.25%), Urticaceae (1.84%), Chenopodiaceae/Amaranthaceae (1.80%) and Asteraceae (1.02%) were most found in the atmosphere of Bilecik making up to 17.91% of the total (Table 1, Fig. 2).

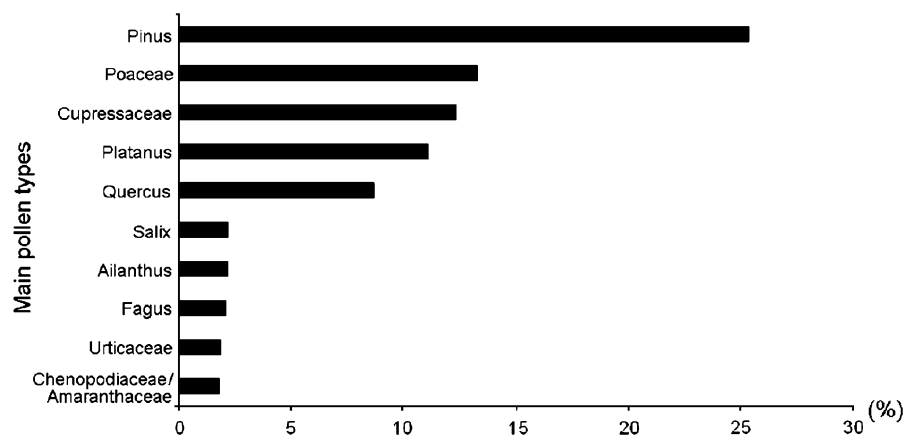
Seasonal pollen variations in arboreal and non-arboreal plants (2005–2006) are shown in Fig. 3. The

earliest pollen releasing to Bilecik atmosphere were noted in January. Main arboreal pollen grains of Cupressaceae, *Fraxinus* sp., *Alnus* sp., and *Coryllus* sp. were observed during this month in small amounts. Number of pollen grains started to increase in February, March and April and reached the highest level in May. Cupressaceae, *Pinus* sp., *Platanus* sp., *Quercus* sp., Poaceae and *Salix* sp. disperse high amount of pollen into the Bilecik atmosphere during their pollination periods and contributed more than 50% of the total grains in May. In June, number of pollen grains was still at high levels. *Pinus* sp. and Poaceae make important contribution to the total pollen number in this month. Cupressaceae, *Ailanthus* sp., *Castanea* sp., Oleaceae and *Tilia* sp. were other important arboreal contributors and Urticaceae, Chenopodiaceae/Amaranthaceae, Asteraceae, *Plantago* sp., *Rumex* sp., Apiaceae, Brassicaceae and *Typha* sp. were non-arboreal contributor to the pollen number in June. In July, high levels of pollen grains were observed. *Pinus* sp. and Poaceae are still major contributors to the pollen amount in July. In August, *Pinus* sp., Poaceae, Urticaceae, Chenopodiaceae/Amaranthaceae, Asteraceae and *Xanthium* sp. were dominant in the atmosphere of Bilecik. In November, low quantities of *Cedrus* sp. pollen grains were recorded. There was no pollen record in December (Table 2, Figs. 2 and 3).

Figure 4 shows the pollen calendar of Bilecik province based on the total counts made in 2005–2006. The following taxa produced the greatest amount of pollen:

1. *Ailanthus* sp.: Pollen season for *Ailanthus* sp. started in the third week of May and ended in

Fig. 2 Annual mean values of the main pollen types in the atmosphere of Bilecik



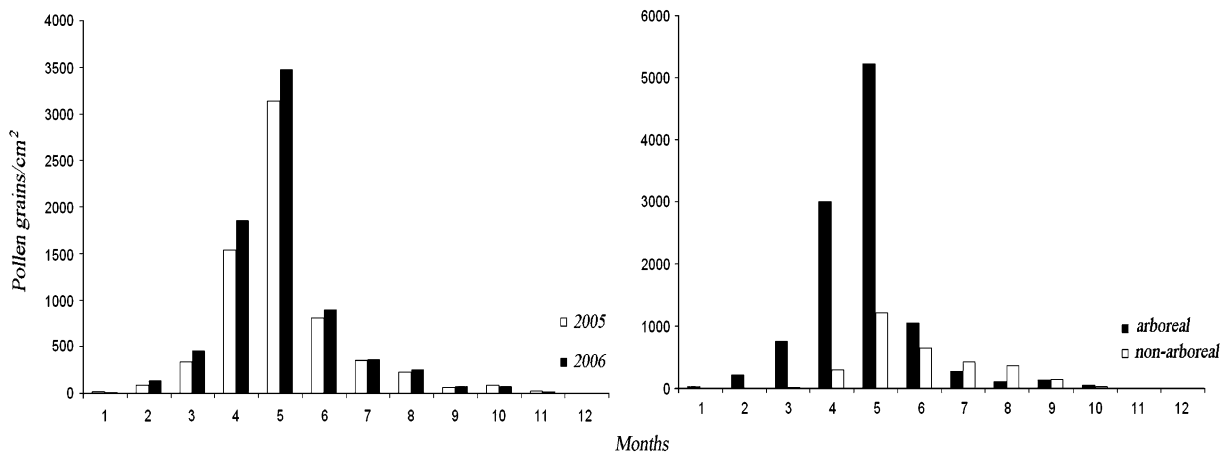


Fig. 3 Monthly variation in total number of pollen grains and arboreal-non arboreal pollen grains in the atmosphere of Bilecik

the third week of July. The highest counts were noted in the first and second weeks of June.

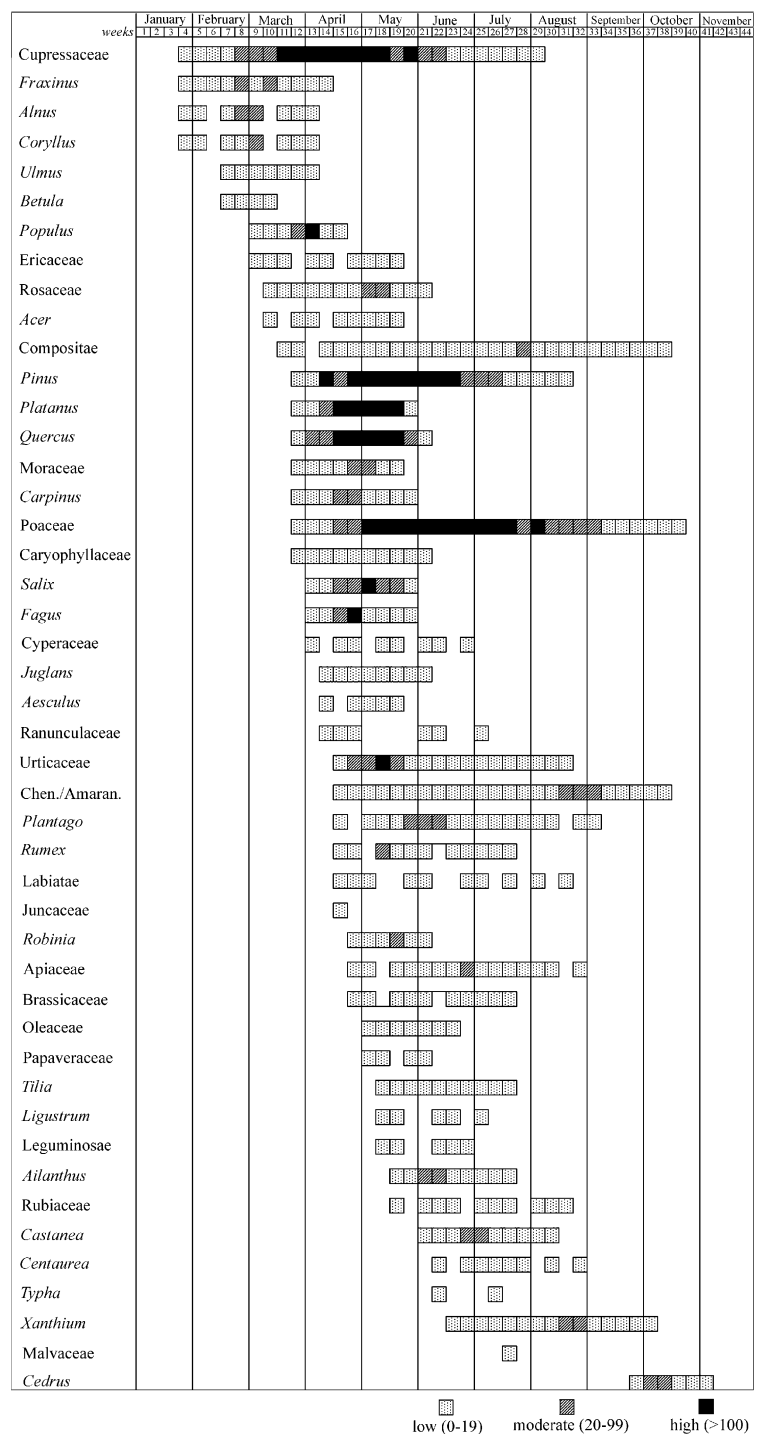
2. *Asteraceae*: Pollen production of *Asteraceae* started in the third week of March and ended in the second week of October. The highest counts were recorded in July.
3. *Cedrus* sp.: Pollen season for *Cedrus* started in the last week of September and ended in the first week of November. The highest counts were recorded in the first and second weeks of October.
4. *Chenopodiaceae/Amaranthaceae*: Pollen season for *Chenopodiaceae/Amaranthaceae* started in

the third week of April and ended in the second week of October. The highest counts were recorded between the third week of August and the first week of August.

5. *Cupressaceae*: Pollen season for *Cupressaceae* started in the last week of January and ended in the first week of August. The highest counts were noted between the third week of March and the last week of May.
6. *Fagus* sp.: Pollen production of *Fagus* started in the first week of April and ended in the last week of May. The highest counts were recorded in the last week of April.

Table 2 The highest airborne pollen concentration in consecutive months and their yearly composition (%), Bilecik, Turkey

Taxa	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (%)
<i>Ailanthus</i>					0.31	1.18	0.67						2.15
<i>Asteraceae</i>			0.03	0.13	0.11	0.10	0.27	0.31	0.05	0.03			1.02
<i>Cedrus</i>										0.87	0.31		1.18
<i>Cheno./Amaranth.</i>					0.05	0.22	0.34	1.00	0.15	0.06			1.80
<i>Cupressaceae</i>	0.08	0.77	2.89	4.63	3.17	0.57	0.17	0.05					12.34
<i>Fagus</i>				1.37	0.71								2.08
<i>Moraceae</i>			0.10	0.54	0.80								1.44
<i>Pinus</i>			0.23	7.53	14.46	1.69	0.84	0.59					25.33
<i>Platanus</i>				0.33	8.21	2.54							11.07
<i>Poaceae</i>			0.04	1.36	6.18	2.75	1.61	0.85	0.38	0.08			13.25
<i>Quercus</i>			0.14	2.71	5.39	0.43							8.67
<i>Rosaceae</i>			0.06	0.34	0.56	0.11							1.07
<i>Salix</i>				0.76	1.41								2.17
<i>Urticaceae</i>				0.20	1.17	0.30	0.13	0.04					1.84
Total	0.08	0.77	3.48	19.90	42.52	9.89	4.02	2.82	0.57	1.04	0.31	0.00	85.41
Others	0.08	0.71	1.81	2.78	1.82	2.87	1.01	0.53	0.48	0.03	0.00	0.00	12.12
Unidentified	0.00	0.06	0.20	0.59	1.21	0.13	0.17	0.07	0.03	0.01	0.00	0.00	2.47
Total	0.16	1.53	5.49	23.27	45.55	12.89	5.20	3.43	1.09	1.08	0.31	0.00	100.00

Fig. 4 Pollen calendar of Bilecik

7. *Moraceae*: Pollen season for *Moraceae* started in the last week of March and ended in the third week of May. The highest counts were noted in the last week of April and the first week of May.

8. *Pinus* sp.: Pollen season for *Pinus* started in the last week of March and ended in the third week of August. The highest counts were recorded between the second week of April to the third week of June.

9. *Platanus* sp.: Pollen production of *Platanus* started in the last week of March and ended in the last week of May. The highest counts were noted between the third week of April and third week of May.
10. Poaceae: Poaceae pollen grains were recorded during the greater part of the year, from March to October. The highest counts were noted between in May and second week of August.
11. *Quercus* sp.: Pollen season for *Quercus* sp. started in the last week of March and ended in the first week of June. The highest counts were recorded between the third week of April and the third week of May.
12. Rosaceae: Pollen season for Rosaceae started in the second week of March and ended in the first week of June. The highest counts were noted in the first and second weeks of May.
13. *Salix* sp.: Pollen production of *Salix* started in the first week of April until the last week of May. The highest counts were recorded in the first week of May.
14. Urticaceae: Pollen season for Urticaceae started in the third week of April and lasted at the third week of August. The highest counts were noted in the second week of May (Table 2, Fig. 4).

Discussion

Dominancy of arboreal pollen types in the atmosphere of Bilecik is the character of the vegetation and the geographical location of the study area. *Pinus* sp. (25.33%), Cupressaceae (12.34%), *Platanus* sp. (11.07%), *Quercus* sp. (8.67%), *Salix* sp. (2.17%), *Ailanthus* sp. (2.15%), *Fagus* sp. (2.08%), Moraceae (1.44%) and *Cedrus* sp. (1.18%) were frequently found arboreal pollen types. Poaceae (13.25%), Urticaceae (1.84%), Chenopodiaceae/Amaranthaceae (1.80%) and Asteraceae (1.02%) were among the major non arboreal contributors to the total pollen grains in the atmosphere of Bilecik.

Arboreal pollen types are also dominant not only in close cities to the research area in Turkey, i.e. 81% in Eskişehir (Erkara et al. 2007), 90% in Sivrihisar (Erkara 2007), 79% in Bozüyük (Türe and Şalkurt 2005), 83% in Kütahya (Bıçakçı et al. 1999), 79% in Bursa (Bıçakçı et al. 2003), 70% in Sakarya (Bıçakçı 2006),

80% in Ankara (Pinar et al. 1999), but also some countries in Europe, i.e. 69.7% in Thessaloniki, Greece (Damialis et al. 2005), 82.0% in Finland (Koivikko et al. 1986), 55.0% in Ascoli Piceno, Italy (Romano et al. 1988) and 73.0% in Ostrawiec Swietokrzyski, Poland (Kasprzyk 1996). In Europe as in Turkey, some taxa like Poaceae, *Alnus* sp., Urticaceae, *Betula* sp., Oleaceae, *Pinus* sp., *Platanus* sp., *Plantago* sp., Cupressaceae, *Coryllus* sp. and *Quercus* sp. were reported among the dominant airborne taxa (Newmark and Itkin 1967; D'Amato et al. 1983; Bousquet et al. 1984, 1986; Eriksson et al. 1984; Koivikko et al. 1986; Romano et al. 1988; Gioulekas et al. 1991; Kasprzyk 1996; Bıçakçı et al. 2005).

When the main pollination period of the various types determined in Bilecik is considered, it can be seen that three groups can be distinguished: (1) pollen with a short principal period <10 weeks: Juncaceae, Malvaceae, *Typha* sp., *Betula* sp., Papaveraceae, *Aesculus* sp., *Ligustrum* sp., Leguminosae, Ranunculaceae, *Robinia* sp., *Cedrus* sp., *Ulmus* sp., *Populus* sp., Oleaceae, *Alnus* sp., *Coryllus* sp., *Acer* sp., Moraceae, *Salix* sp., *Fagus* sp., Cyperaceae, *Juglans* sp., *Centaurea* sp., Ericaceae, *Platanus* sp., *Carpinus* sp. and *Ailanthus* sp.; (2) pollen with a medium principal period, between 10 and 17 weeks: *Fraxinus* sp., *Rumex* sp., Rosaceae, Apiaceae, *Xanthium* sp., Urticaceae and *Plantago* sp.; (3) pollen with a long principal period >17 weeks: *Pinus* sp., Chenopodiaceae/Amaranthaceae, Cupressaceae, Asteraceae and Poaceae (Fig. 4).

Pollen is the most important aeroallergen throughout Europe. Its relative contribution to pollinosis varies regionally in relation to local vegetation type, agriculture and climate (Spieksma 1990; Docampo et al. 2007). Although they represent only a small proportion of the airborne particles present in the atmosphere, pollen grains can cause some allergic responses in susceptible humans (D'Amato and Spieksma 1990, 1992; Armentia et al. 2004; D'Amato et al. 2007; Rodríguez et al. 2007). In this study, some important allergenic pollens of certain plants like *Pinus* sp., Poaceae, *Platanus* sp., *Quercus* sp., *Acer* sp., Moraceae, *Urtica* sp., *Fraxinus* sp., Chenopodiaceae/Amaranthaceae, Cupressaceae and *Juglans* sp. were found (Fig. 4) Among these allergic pollen releasing plants, some groups such as Poaceae (Chapman 1986; Ruden and Steinman 2004), *Pinus* sp. (Newmark and Itkin 1967; Harris and German

1985; Freeman 1993; Marcos et al. 2001), Cupressaceae (Leventin and Buck 1980; Bousquet et al. 1984; Spieksma 1990), Chenopodiaceae/Amaranthaceae (Leventin and Buck 1980; Colás et al. 2005) and Asteraceae (Lewis and Vinay 1979; Aytuğ et al. 1990) are more important than the most other plants because of long pollination period and strong allergic effects (hayfever, pollinosis, asthma, etc.). The following airborne pollens may cause many cases of allergic reactions: *Quercus* (Eriksson et al. 1984; Zawisza and S-Zawisza 1991; Weryszko-Chmielewska et al. 2006), Moraceae (Aytuğ et al. 1990), *Juglans* (Aytuğ and Peremeci 1987), *Platanus* (Chapman and Williams 1984), Caryophyllaceae (Lewis and Vinay 1979; Aytuğ et al. 1990), Urticaceae (Bousquet et al. 1984; Wallin et al. 1991), *Fagus* and *Salix* (İnce 1994).

Information obtained from these kinds of studies will help us to determine both the knowledge of the distribution mechanisms of pollens and minimizing the negative effect on the health of pollen sensitive people and understanding the biology-behavior of pollen grains in the atmosphere. The pollen calendar presented in this paper may be useful for allergologists and people living in Bilecik province.

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