Concentrations of Airborne Pollen Grains in Eskisehir City (Turkey)*

Ismuhan POTOGLU ERKARA[1] Sevil PEHLIVAN[2] Suleyman TOKUR[1]
[1] Eskişehir Osmangazi University, Faculty of Science and Art, Department of Biology, 26480, Meselik, Eskisehir, TURKEY
[2] Gazi University, Faculty of Science and Art, Department of Biology, 06500, Ankara, TURKEY
E-mail: ismuhan@ogu.edu.tr

*This is the Ph. D dissertation thesis of Ismuhan Potoglu Erkara's titled as "Airborne Pollen Grains of Eskisehir".

Received : 26 May 2006
Accepted : 15 July 2006

Abstract

Pollen grains found in the air of Eskisehir were studied for two years (January 2000-December 2001) with a Durham sampler. During this period, a total of 47,082 pollen grains belonging to 45 taxa were recorded. Of these 45 taxa, 26 belonged to arboreal and 19 to non-arboreal plants, of which 19,141 were identified in 2000 and 27,941 in 2001. Of the total number of pollen grains, 81 % were arboreal and 18 % non-arboreal, while 1 % could not be identified. The majority of the investigated pollen grains as families came from Pinaceae, Chenopodiaceae/ Amaranthaceae, Cupressaceae, Gramineae, Rosaceae, Fabaceae, Oleaceae, Cruciferae, Compositae, Urticaceae, Ulmaceae, Cistaceae, Moraceae, with the genera being *Salix*, *Quercus*, *Ailanthus*, *Fraxinus*, *Fagus, Populus*, *Platanus*, *Cedrus*, *Artemisia*, *Corylus*, *Plantago*, *Juglans*, *Acer* and *Carpinus* respectively. Pollen concentrations reached their highest levels in May (54.36 %).

Key words: Aerobiology, Pollen, Pollen calendar, Pollen allergy.

INTRODUCTION

During the last decade clear evidence has emerged that there has been an increase in the incidence of pollen allergy in most European countries and that this trend is particularly noticeable in urban areas [1]. Pollen is the most significant aeroallergen found throughout Europe, although its relative contribution to pollinosis varies regionally in relation to local vegetation type, agriculture and climate [1-13].

Pollen allergy is an increasing problem, with the main pollen types causing rhinitis and asthma. People who are allergic to pollen often ask exactly when is it advisable to stay indoors in order to minimize exposure to pollen. In an attempt to answer such a question, airborne pollen grains were collected from different locations in Eskisehir and studied. It would be expected that the concentration of airborne pollen be lower during the early morning and then increase to a maximum in the middle of the day or early evening, showing a rather smooth curve, as recently described by authors in other countries [14-16]. Weather conditions such as temperature, wind velocity and strength, relative humidity, rainfall are all known to have a strong influence on the timing of pollen liberation. Furthermore, the position of the pollen sampler to the plants producing pollen influences the amount of pollen collected [4, 15-20].

This study aims to: compare the relative importance of the controlling variables in each area; determine the extent to which the relationships between the variables change in different stations, both within each individual study area and between the climatic regimes; evaluate the extent to which specific area models are applied, and determine the extent to which common relationships can be used to establish a pollen calendar for Eskisehir.

MATERIALS AND METHODS

Eskisehir is situated between 39º06' and 40º09' N, 29º58' and 32º04' E in the Northwest of Turkey (Fig.1), at an altitude 788m. Eskisehir has a Mediterranean, Irano-Turanion vegetation and generally a Mediterranean climate.

The meteorological data for Eskisehir was obtained from the Eskisehir Meteorological Service, which has been continually monitoring meteorological observations since 1940. For the period 1940 – 2001, the annual average rainfall was 294.1mm; average temperature 10.8 ^{o}C; the warmest month was July with an average temperature of 21.5 ^{o}C; annual average humidity 67 %; and predominant wind directions at the sampling site were west-northwest between March-October and east-southeast between November-February.

For the purposes of the study the gravimetric method and a Durham sampler were used [21-22]. The Durham sampler was placed at a height of 1.75 m above ground level in the three stations (1. Osmangazi University Meselik Campus; 2. Anadolu University Yunus Emre Campus; 3. Anadolu University İki Eylül Campus) (Fig 1). The first station is rich in flora, with 240 plant species and 41 varieties, the most common being the Pinaceae, Asteraceae, Fabaceae, Brassicaceae, Lamiaceae, Boraginaceae, Poaceae and Rosaceae families. Latitude: 39^{o} 48' N, Longitude: 30^{o}32' E, Altitude: 845 m. There are 363 plant species at the second station where the Pinaceae, Cupressaceae, Asteraceae, Fabaceae, Lamiaceae Poaceae, Aceraceae, Betulaceae, Rosaceae, Fagaceae, Ranunculaceae, Oleaceae, Salicaceae, Ulmaceae and Moraceae families are the most common. Latitude: 39^{o} 47' N, Longitude: 30^{o}29' E, Altitude: 819 m. The third station is situated in a residential area, but some plant species belonging to the Pinaceae, Poaceae, Asteraceae, Fabaceae Linaceae, Apiaceae, Lamiaceae, Brassicaeae, Boraginaaceae, Plantaginaceae, Scrophulariaceae, Caryophyllaceae, Ranunculaceae, Malvaceae, Papaveraceae, Rosaceae, Convolvulaceae and Scrophulariaceae families are common [11, 23-28]. Latitude: 39^{o} 44' N, Longitude: 30^{o}29' E, Altitude: 789 m. The first station is in the south of the city, but the second and third stations are in the north. The distances between the research stations and a meteorological station were measured with a GARMIN GPS 12 CX device (Global Positioning System; Made in Taiwan, under USA patent). This device was also used to measure the altitude of the research stations.

In addition to the natural vegetation of Eskisehir, the following species are also frequently seen in the parks, gardens and streets of the city: *Acacia* spp (Wattle), *Acer* spp (Maple), *Aesculus hippocastanum* (Common Horse

Chestnut), *Ailanthus altissima* (Tree of Heaven), *Alnus glutinosa* (Common Alder), *Betula* spp (Birch), *Carpinus betulus* (Hornbeam), *Castanea sativa* (Chestnut), *Cedrus libani* (Lebanese Cedar), *Cercis siliquastrum* (Judas Tree), *Cornus mas* (Cornus), *Corylus* spp (Hazelnut), *Cupressus sempervirens* (Italian Cypress), *Eleagnus angustifolia* (Oleaster), *Fagus orientalis* (Oriental Beech), *Fraxinus excelsior* (Common Ash), *Forsytia* spp, *Juglans regia* (Walnut), *Juniperus* spp (Juniper), *Ligustrum vulgare* (Common Privet), *Lonicera* spp (Honeysuckle), *Morus alba* (White Mulberry), *Olea europea* (Olive Tree), *Platanus orientalis* (Oriental Plane), *Populus tremula* (Tremulous Poplar), *Prunus domestica* (Plum), *Quercus* spp (Oak), *Salix babylonica* (Chinese Weeping Willow), *Thuja* spp (Arborvitae), *Tilia tomentosa* (Silver Lime) and *Ulmus* spp (Linden).

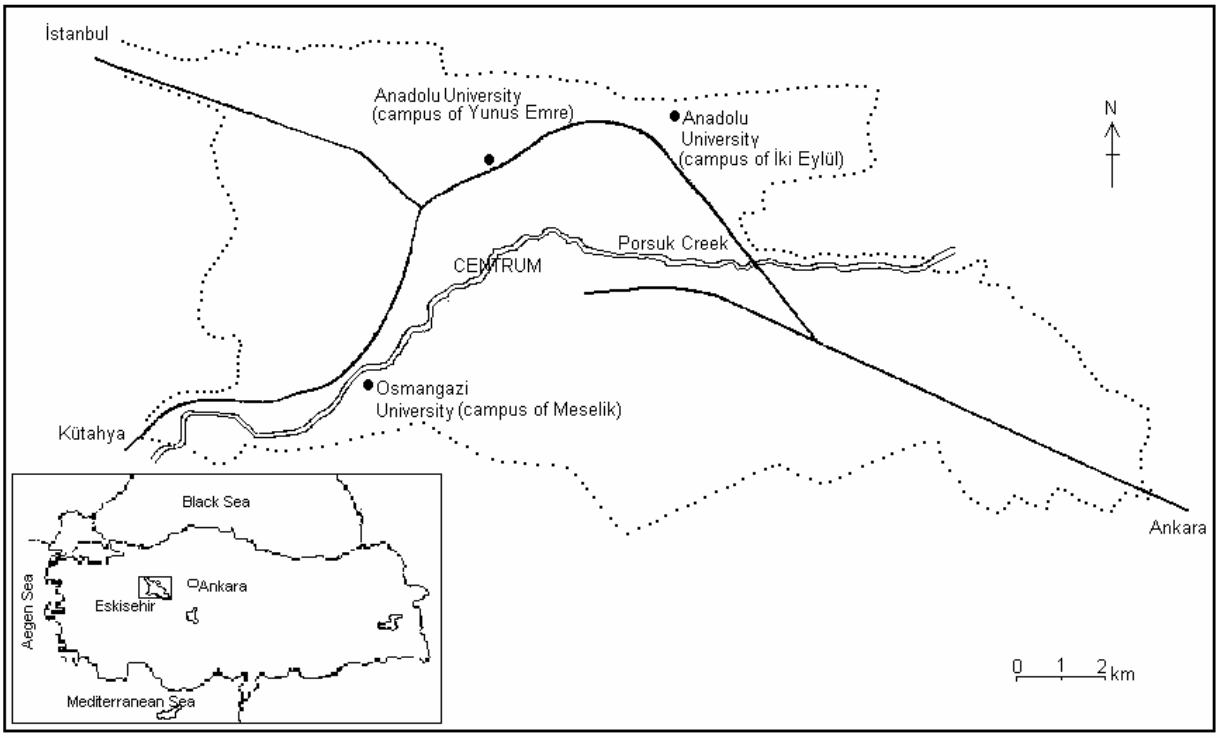

Figure 1. A map of Eskisehir city (Turkey) showing the province of Eskisehir. The research stations are: 1. Osmangazi University Meselik Campus; 2. Anadolu University Yunus Emre Campus; 3. Anadolu University Iki Eylul Campus.

Slides placed on the Durham sampler were changed daily. Before exposure, the slides were covered with glycerine jelly mixed with basic fuchsin [29]. The slides were examined daily under a light microscope. The identification and counting of pollen grains was determined to at least family and genus levels. Grains that could not be identified were considered unidentified types. The number of pollen grains found in the glass area (22 mm X 22 mm) was counted.

RESULTS

A total of 47 082 pollen grains from 45 taxa were identified in Eskisehir's atmosphere between 1 January 2000 and 31 December 2001, 19,141 in 2000 and 27,941 in 2001. From these 45 taxa, it was established that 26 of the plants were arboreal and 19 non-arboreal, and analysis of the pollen grains revealed that 38 519 were arboreal (81%) and 8 275 non-arboreal (18%), with 288 unidentified (1%). When breaking these numbers down into samples found at the individual testing stations, we found that: of the 6885 pollens of 42 taxa determined on the Meselik Campus of Osmangazi University, 2543 were found in 2000 and 4342 in 2001; for the Yunus Emre Campus of Anadolu University, of the 29,246 pollens from 44 taxa determined: 11,387 were found in 2000 and 17,859 in 2001; while at Anadolu University's 2nd site, that of the Iki Eylul campus, of the 10 960 pollens belonging to 44 taxa determined, 5208 in 2000 and 5752 in 2001 (Table 1, 2). Arboreal pollen types were dominant due to the vegetation and geographical location of the city. Monthly variations of total pollen grains recorded in the atmosphere of Eskisehir during the years 2000-2001 are shown in Fig 2. The seasonal variation of arboreal and non-arboreal pollen falls is given in Fig 3.

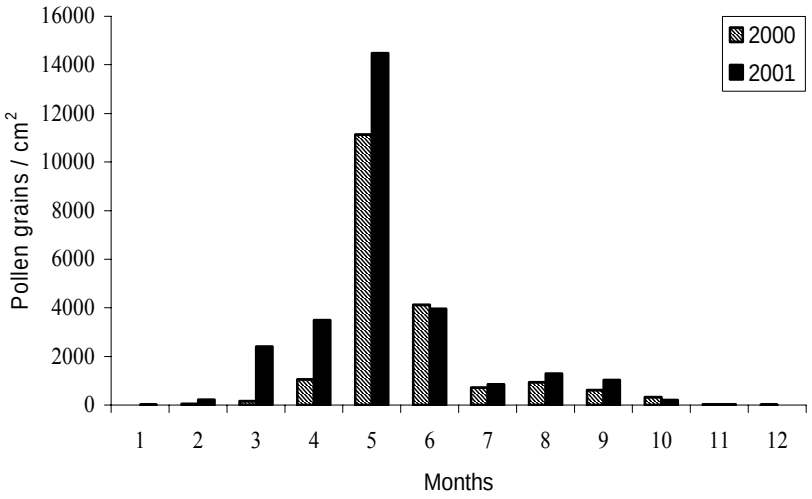

Figure 2. Monthly totals of atmospheric pollen in Eskisehir, 2000-2001.

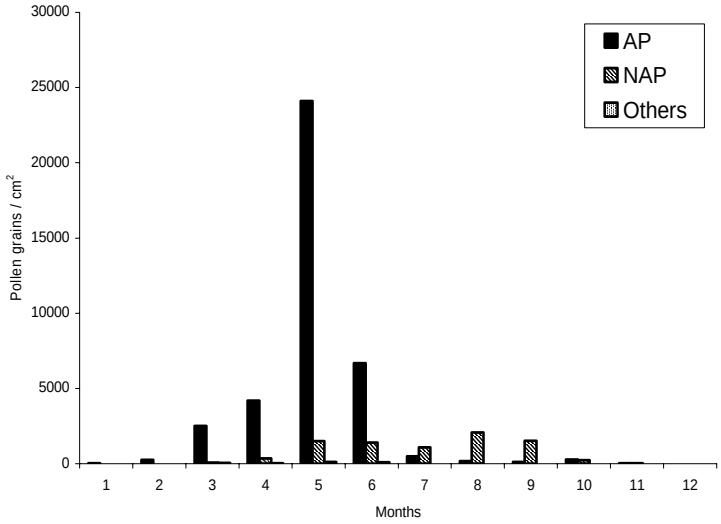

Figure 3. Monthly variations of arboreal (AP) and non-arboreal (NAP) pollen grains in Eskisehir, 2000-2001.

The main pollen producers in the atmosphere of Eskisehir were found to be the following arboreal plants: Pinaceae (48.13 %), *Salix* (9.16 %), Cupressaceae (6.21 %), Rosaceae (3.53 %), *Quercus* (3.03 %), *Ailanthus* (1.95 %), *Fraxinus* (1.59 %) and *Fagus* (1.58 %), forming 81.14 % of the total pollen fall. Pollen from herbaceous plants, such as Chenopodiaceae/Amaranthaceae (7.82 %), Gramineae (4.22 %), Fabaceae (1.97 %), Cruciferae (0.85 %), Compositae (0.61 %), Urticaceae (0.54 %), *Artemisia* (0.43 %) and *Plantago* (0.38 %) were found frequently in the atmosphere of Eskisehir, making up 16.82 % of the total (Table 1, 2). Arboreal pollen grains were more profuse than non-arboreal in total pollen concentrations. Arboreal pollen grains reached maximum levels in May, while non-arboreal pollen grains reached maximum levels in August (Fig 3, Table 1, 2).

The earliest pollen grains to be found in the atmosphere of Eskisehir were noted in January in 2001 (Fig. 4), and were from the predominant arboreal group. Pollen grains began to increase in February, March and April, peaking in May (11,130 pollen grains in 2000, and 14,468 in 2001). *Pinus*, Gramineae, Cupressaceae, *Platanus*, Oleaceae, *Quercus,* Moraceae and Urticaceae disperse high amounts of pollen, more than 54.36%, into the atmosphere throughout their pollination period, particularly in May. The amount of pollen grains found in the air was also high in June. From the beginning of July, the pollen grains of weeds became dominant; however, the amount of pollen was lower than that of spring. An explanation for this decrease after June may be that June is the climax of the pollination period for many of the arboreal plants producing and releasing high amounts of pollen grains into the atmosphere (Fig 3). In July, the non-arboreal pollen grains from Gramineae, Urticaceae, Compositae, *Rumex* sp., Umbelliferae, Fabaceae, Chenopodiaceae/Amaranthaceae and *Artemisia* were observed alongside arboreal pollen grains from *Ailanthus*, Cupressaceae, Pinaceae and *Cedrus*. High amounts of pollen grains from Chenopodiaceae/Amaranthaceae, *Cedrus* sp., and *Artemisia* sp. were recorded in August-October and low quantities of pollen grains for *Cedrus* sp., Gramineae, Compositae, Chenopodiaceae/Amaranthaceae and *Artemisia* sp. were recorded in November. Low measurements of Gramineae, Chenopodiaceae/Amaranthaceae and *Cedrus* sp. were recorded in December.

Pollen levels in the atmosphere of Eskisehir were continuously monitored between January and December for the two year study period. Total pollen grains reached maximum levels in May during this period. The types of pollen present in the atmosphere of Eskisehir are shown in the form of a pollen calendar (Fig 4), based on the counts made in 2000-2001.

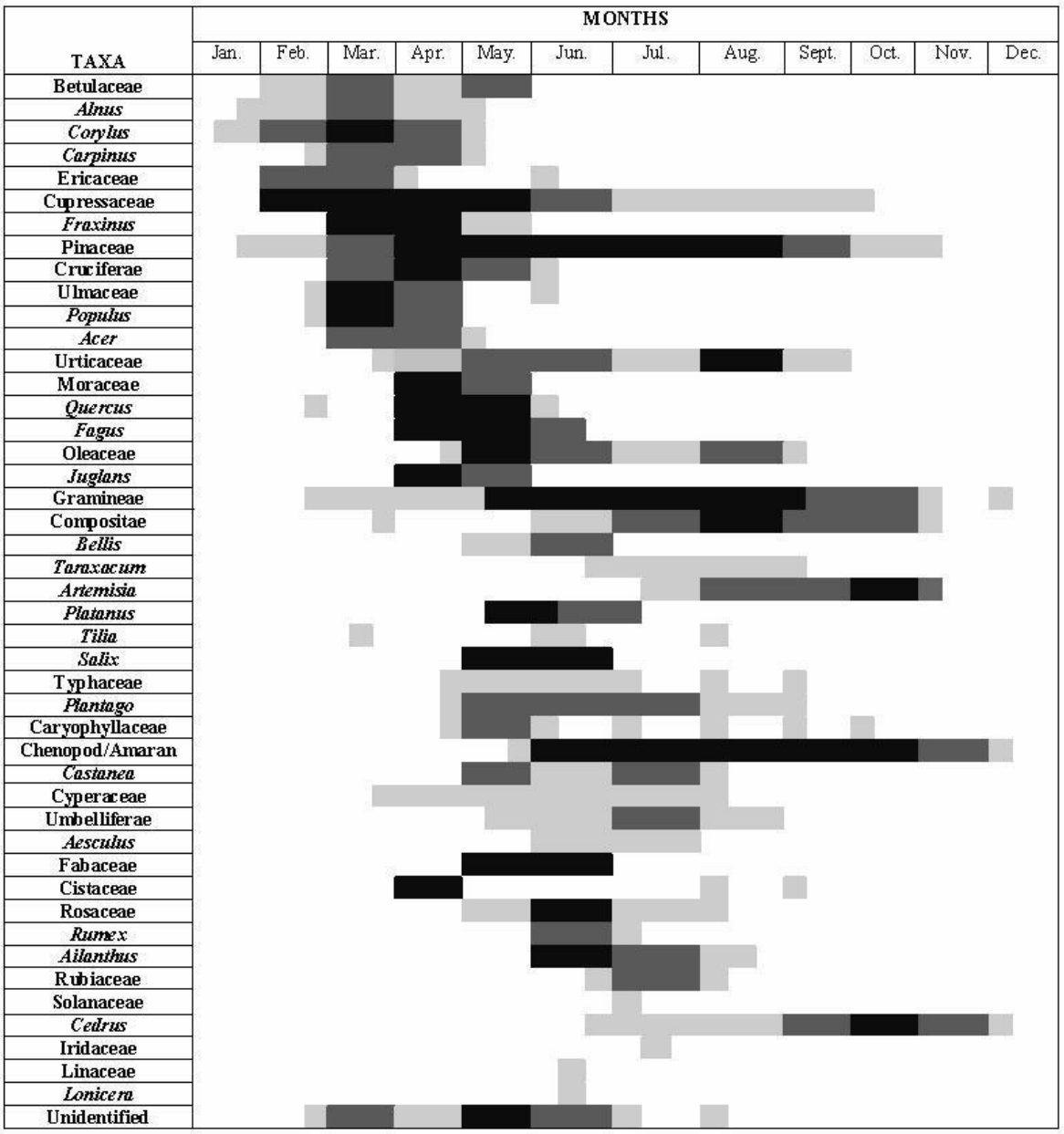

Figure 4. Pollen calendar of Eskisehir.

The following are the taxa producing the highest amounts of pollens in the atmosphere of Eskisehir.

Pinaceae: Pollen grains were recorded during the greater part of the year, from January to November. The pollen season begining in the second week of January and ended in the last week of November. The highest value was noted in the second week of May (48.13 %).

***Salix*:** The pollen season started in the first week of May and ended in the last week of June. The pollen concentration reached its maximum level in the third week of May (9.16 %).

Chenopodiaceae/ Amaranthaceae: The pollen season started in the third week of May and ended in the first week of December. The pollen concentration reached its maximum level in the first week of August (7.82 %).

Cupressaceae: The pollen season started in the second week of February and ended in the first week of October. The maximum value was recorded in the second week of April (6.21 %).

Gramineae: Pollen grains were recorded in the second week of February and ended in the first week of December. The highest count was recorded in the first week of June (4.22 %).

Rosaceae: Pollen production continued from the second week of May to the third week of August. The maximum value was recorded in the second week of June (3.53 %).

***Quercus*:** The pollen season started in the last week of February and ended in the first week of June. The highest pollen concentration was noted in the second week of May (3.03 %).

Fabaceae: Pollen production continued from the second week of May to the third week of June. The maximum value was recorded in the second week of May (1.97 %).

***Ailanthus*:** Pollen grains were recorded in the first week of June and ended in the first week of August. The highest count was recorded in the second week of June (1.95 %).

***Fraxinus*:** The pollen season started in the first week of March and ended in the second week of May. The maximum value was recorded in the second week of March (1.59 %).

***Fagus*:** The pollen season started in the second week of April and ended in the second week of June. The maximum pollen concentration was recorded in the second week of May (1.58 %).

The correlation between the monthly pollen concentration and the monthly meteorological factors over the period January 2000-December 2001 is shown in Fig 5.

Since temperature and wind speeds are low in January and February, pollen counts are correspondingly low. Low temperatures drop pollen concentration [18-19]. In March, there was a significant increase in the number of pollen grains, which can also be correlated to the higher temperatures and wind speed seen in comparison with the previous months.

Pollen concentrations in April were different from those in March, with a significant increase occurring at the beginning of April. However, by the third week of April, the heavy rain, lower wind speed and temperature and higher humidity again lower the pollen amount. This was reflected in our results, where a small decline was seen in pollen concentration in April, explained by the lower wind speeds and the temperature (Fig 5).

The peak for concentration of pollens in the air was found in May, when lower rainfall and humidity, and higher temperatures and wind speeds contribute to increasing pollen concentration (Fig 5).

In June, the increase in total pollen quantity was caused by the beginning of the pollination of herbs and the maximum pollen dispersal of Gramineae, Urticaceae, Compositae, *Rumex* sp., Umbelliferae, Fabaceae, Chenopodiaceae/Amaranthaceae and *Artemisia*. The low humidity and rainfall, high temperature and wind speeds of June raised the pollen counts, while the rainfall of April also contributed by increasing flowering intensity [9, 11, 14]. The lower pollen concentration seen in July is attributed to a decline in pollen production by trees at the end of the flowering season rather than to weather conditions.

There was a small increase in the pollen concentration of herbs between August and October (Fig 5) due to the higher temperatures and wind speeds, which raised pollen amounts for the herbs. In November and December, the very low values of airborne pollen were recorded due to these months having higher rainfall and the lower temperatures than other months.

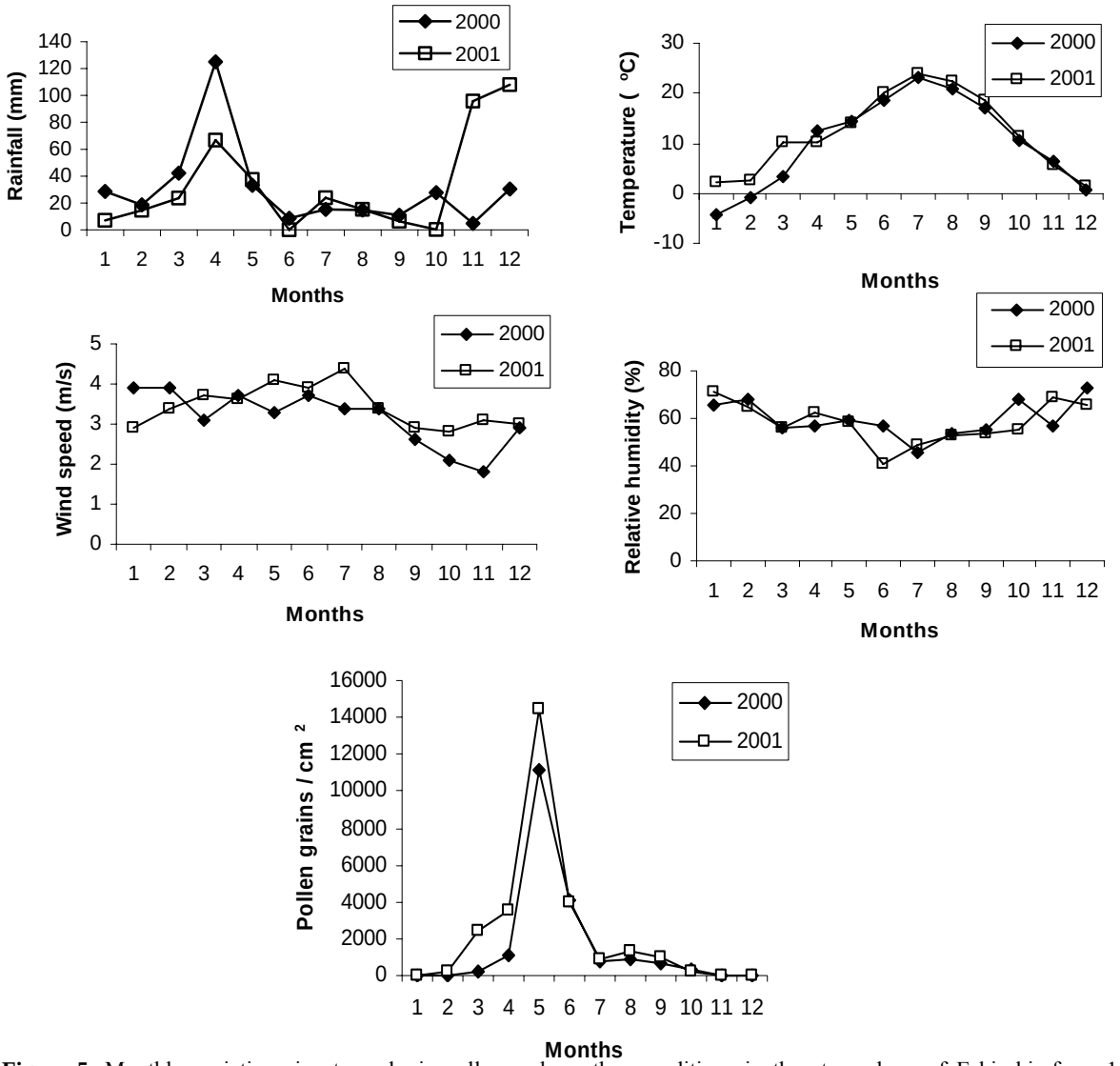

Figure 5. Monthly variations in atmospheric pollen and weather conditions in the atmosphere of Eskisehir from 1 January 2000 to 31 December 2001.

Table 1. Annual totals of daily pollen counts of arboreal plants.

	Meselik Campus				Yunus Emre Campus				Iki Eylul Campus				The whole city of Eskisehir			
Arboreal plants (AP)	2000	2001	Total	Total %	2000	2001	Total	Total %	2000	2001	Total	Total %	2000	2001	Total	Total %
Acer	7	20	27	0,392	8	57	65	0,222	2	24	26	0,237	17	101	118	0,25
Aesculus	3	0	3	0,044	1	2	3	0,01	1	0	1	0,009	5	2	7	0,01
Ailanthus	11	17	28	0,407	744	134	878	3,002	4	9	13	0,118	759	159	918	1,95
Alnus	5	10	15	0,218	10	17	27	0,092	5	20	25	0,228	20	47	67	0,14
Betulaceae	10	5	15	0,218	10	22	32	0,109	3	33	36	0,328	23	59	82	0,17
Carpinus	5	17	22	0,32	19	40	59	0,202	7	22	29	0,264	31	79	110	0,23
Castanea	0	6	6	0,087	13	18	31	0,106	4	24	28	0,255	17	48	65	0,14
Cedrus	26	16	42	0,61	240	42	282	0,964	21	16	37	0,337	287	74	361	0,77
Cistaceae	1	0	1	0,015	2	219	221	0,756	1	0	1	0,009	4	219	223	0,47
Corylus	20	23	43	0,625	20	63	83	0,284	26	50	76	0,693	66	136	202	0,43
Cupressaceae	241	981	1222	17,75	276	873	1149	3,929	179	374	553	5,045	696	2228	2924	6,21
Ericaceae	12	21	33	0,479	5	38	43	0,147	1	14	15	0,136	18	63	81	0,17
Fagus	18	129	147	2,135	44	277	321	1,098	52	227	279	2,545	114	630	744	1,58
Fraxinus	24	41	65	0,944	118	442	560	1,915	37	87	124	1,131	179	570	749	1,59
Juglans	3	26	29	0,421	31	44	75	0,256	12	26	38	0,346	44	96	140	0,30
Moraceae	1	21	22	0,32	3	104	107	0,366	8	33	41	0,374	12	158	170	0,36
Oleaceae	19	99	118	1,714	38	132	170	0,581	32	108	140	1,277	89	339	428	0,91
Pinaceae	1441	1537	2978	43,25	7296	6666	13962	47,74	3215	2505	5720	52,189	11952	10708	22660	48,13
Platanus	30	40	70	1,017	68	109	177	0,605	85	69	154	1,405	183	218	401	0,85
Populus	10	70	80	1,162	34	209	243	0,831	20	68	88	0,802	64	347	411	0,87
Quercus	106	177	283	4,11	250	399	649	2,219	161	333	494	4,507	517	909	1426	3,03
Rosaceae	3	7	10	0,145	6	1633	1639	5,604	4	7	11	0,100	13	1647	1660	3,53
Salix	9	351	360	5,229	800	3100	3900	13,34	25	28	53	0,483	834	3479	4313	9,16
Tilia	3	1	4	0,058	3	4	7	0,024	1	3	4	0,036	7	8	15	0,03
Typhaceae	0	1	1	0,015	2	2	4	0,014	6	6	12	0,109	9	9	18	0,04
Ulmaceae	1	115	116	1,685	38	56	94	0,321	3	30	33	0,301	42	201	243	0,52
Total (AP)	2009	3731	5740	83,37	10009	14702	24781	84,737	3915	4116	8031	73,275	16002	22534	38536	81,84

Table 2. Annual totals of daily pollen counts of non-arboreal plants.

	Meselik Campus				Yunus Emre Campus				Iki Eylul Campus				The whole city of Eskisehir			
Non-arboreal plants (NAP)	2000	2001	Total	Total %	2000	2001	Total	Total %	2000	2001	Total	Total %	2000	2001	Total	Total %
Artemisia	16	20	36	0,523	26	39	65	0,222	60	43	103	0,939	102	102	204	0,43
Bellis	7	10	17	0,247	5	7	12	0,041	3	10	13	0,118	15	27	42	0,09
Caryophyllaceae	0	15	15	0,218	3	9	12	0,041	2	22	24	0,218	5	46	51	0,11
Chenopod/Amaran	139	109	248	3,602	748	1428	2176	7,44	546	710	1256	11,459	1436	2247	3683	7,82
Cruciferae	8	7	15	0,218	13	339	352	1,204	15	19	34	0,310	36	365	401	0,85
Compositae	45	20	65	0,944	49	51	100	0,342	73	51	124	1,131	167	122	289	0,61
Cyperaceae	3	3	6	0,087	8	7	15	0,051	9	6	15	0,136	20	19	39	0,08
Fabaceae	81	80	161	2,338	75	500	575	1,966	93	97	190	1,733	249	677	926	1,97
Gramineae	156	231	387	5,621	280	520	800	2,735	312	487	799	7,290	748	1238	1986	4,22
Iridaceae	0	0	0	0	2	0	2	0,007	1	0	1	0,009	3	0	3	0,01
Linaceae	0	0	0	0	0	0	0	0	2	0	2	0,018	2	0	2	0,00
Lonicera	0	0	0	0	0	1	1	0,003	0	0	0	0	0	1	1	0,00
Plantago	7	20	27	0,392	10	48	58	0,198	29	64	93	0,848	46	132	178	0,38
Rubiaceae	3	0	3	0,044	2	0	2	0,007	2	30	32	0,291	8	30	38	0,08
Rumex	8	18	26	0,378	6	21	27	0,092	3	16	19	0,173	17	55	72	0,15
Solanaceae	0	1	1	0,015	0	3	3	0,01	0	2	2	0,018	0	6	6	0,01
Taraxacum	1	0	1	0,015	4	0	4	0,014	0	12	12	0,109	5	12	17	0,04
Umbelliferae	14	17	31	0,45	5	9	14	0,048	15	8	23	0,209	34	34	68	0,14
Urticaceae	37	23	60	0,871	31	98	129	0,441	52	11	63	0,574	120	132	252	0,54
Non-arboreal plants (NAP)	525	574	1099	15,963	1267	3080	4347	14,862	1217	1588	2805	25,593	3013	5245	8258	17,53
Unidentified	9	37	46	0,668	41	77	118	0,403	76	48	124	1,131	126	162	288	0,61
Total (AP+NAP+Un)	2543	4342	6885	100.00	11387	17859	29246	100.00	5208	5752	10960	100.00	19141	27941	47082	100,00

DISCUSSION

The present study will contribute to our knowledge of airborne pollen grains in Eskisehir. Arboreal pollen types were dominant in Eskisehir's environment due to the character of the vegetation and geographical location of the city. The important tree pollen types were Pinaceae (48.13 %), *Salix* (9.16 %), Cupressaceae (6.21 %), Rosaceae (3.53 %), *Quercus* (3.03 %), *Ailanthus* (1.95 %), *Fraxinus* (1.59 %) and *Fagus* (1.58%). Grass pollen appeared with a maximum flowering period from the second week of February to the first week of December. The highest count was recorded in the first week of June. The herb pollen season was recorded from the second week of February to the first week of December. The highest herbaceous pollen peak was recorded from the beginning of May to the beginning of the November, when Chenopodiaceae/ Amaranthaceae (7.82 %), Gramineae (4.22 %), Fabaceae (1.97 %), Cruciferae (0.85 %), Compositae (0.61 %), Urticaceae (0.54 %), *Artemisia* (0.43 %) and *Plantago* (0.38 %) were very abundant in the atmosphere. According to other studies carried out in Europe, arboreal pollen types are also dominant in other regions for the same reason, i.e. Finland 82 % [30], Ankara 76 % [9], Perugia 71 % [32], Bursa 70.01 % [10], and Ascoli Piceno 55 % [31].

According to the main pollination period of the various types recorded, three groups could be distinguished: 1. pollen with a short principal period < 10 weeks: *Acer*, Moraceae, *Juglans*, *Bellis*, *Platanus*, *Salix*, *Aesculus*, Fabaceae, Cistaceae, *Rumex*, Rubiaceae, Solanacae, Iridaceae, Linaceae, *Lonicera*; 2. pollen with a medium principal period, between 10 and 15 weeks: Betulaceae, Alnus, Corylus, *Carpinus*, Ericaceae, Fraxinus, Cruciferae, Ulmaceae, *Populus*, *Quercus*, *Fagus*, *Taraxacum*, *Artemisia*, *Tilia*, Typhaceae, Castanea, Umbelliferae, Rosaceae, *Ailanthus*; 3. pollen with a long principal period > 15 weeeks: Cupressaceae, Pinaceae, Oleaceae, Urticaceae, Gramineae, Compositae, *Plantago*, Caryophyllaceae, Chenopodiaceae/Amaranthaceae, Cyperaceae, *Cedrus*. However, pollen grains from some plants found in the city flora could not be distinguished (11, 26-28), which may be put down to different flowering periods, meteorological factors, the location of the Durham sampler, anthesis and dispersion.

Even though they represented only a small proportion of the airborne particles present in the atmosphere, pollen grains can be the cause of allergic responses in susceptible humans, with pollinosis (ocular rhinitis and asthma) now being a public health problem. *Alnus*, Cupressaceae, *Quercus*, *Platanus*, *Juglans*, Moraceae, Pinaceae, Oleaceae, *Fraxinus*, *Acer*, Gramineae, Chenopodiaceae/ Amaranthaceae, Compositae, Urticaceae, *Plantago*, *Artemisia*, *Rumex*, Umbelliferae, which can all be detected in the atmosphere of Eskisehir, may cause asthma and allergic rhinitis in those individuals susceptible to these pollens [1, 5, 15, 32-36]. The pollen grains of *Salix*, *Populus*, Rosaceae, Cyperaceae, Fabaceae, Cruciferae, *Cedrus*, *Ailanthus*, Caryophyllaceae, Typhaceae taxa have also been shown to produce milder allergic pollen grains in Eskisehir [6, 32-34, 37].

The correlation between the monthly airborne pollen counts and the monthly meteorological factors over the period January 2000-December 2001 clearly indicated that the pollen concentration was affected by all meteorological parameters (wind speed, temperature, rainfall and humidity).

The lower pollen concentration observed can be attributed to high rainfall and humidity and low temperature in April. High and continuous rainfall depressed pollen dispersal. Moreover, the lower wind speed seen during this month also slowed down pollen dispersal in the atmosphere [2, 9, 14, 19-20].

Higher quantities of pollen found in the air samples for 2001 is attributed to greater wind speed, lower rainfall and higher temperatures in the spring than in 2000. The mean wind speed in the spring of 2001 was 4.1 m/s, while it was 3.7 m/s at the same time in 2000. The spring mean temperature for 2001 was 14.1 ^{o}C, while it was 14.2 ^{o}C in the spring of 2000. The mean humidity in the spring of 2001 was 62.3 %, while it was 57.2 % during the same period of 2000. A further reason for the greater amount of pollen recorded in 2001 was the higher precipitation between April 2000 and 2001 (125.1-66.8 mm). Storage of water in the soil during the winter caused plant growth and increased flowering intensity in the spring [14].

Seasonal totals of weekly concentrations for grass pollen were higher in 2001 (1238 grains/ cm^2) than in 2000 (748 grains/ cm^2). This was probably caused by the higher wind speed in July 2001 (4.4 m/s) than in the previous year (3.4 m/s). McDonald [14] has showed that wind velocity has the greatest influence on the amount of grass pollen in the atmosphere.

We determined an increase in the total number of pollens in 2001, which we attributed to the high rainfall that Eskişehir had received for the previous two years (2000-2001). Sunny and rainy weather have been reported to have a positive effect upon the increase in the total number of pollens, as humidity also increases with a rise in temperature. Heavy rain is known to hamper pollination, which results in a far slower growth of pollens in the area affected [9, 14]. A corresponding rise in the number of pollens was recorded with a rise in both temperature and humidity on all the three campuses in the aftermath of rain (Fig 1, 5). Furthermore, periods of zero pollen concentrations in the air are attributed to the fact that a heavy rain cleanses the air [2].

A comparison between the total numbers of pollens on all the three stations showed Yunus Emre to have the highest and Meselik to have the lowest numbers of pollens. We consider this may be due to the fact that the flora of the campus of Yunus Emre is far richer in comparison with other campuses. With the dominant wind direction being west-northwesterly, the campus of Iki Eylul is a dense area with respect to pollen dissemination.

The campuses of Yunus Emre and Iki Eylul are significant in that they are west-northwesterly situated in terms of exposure to the wind and dissemination of pollination from both nearby and remote places. The campus of Meselik, in contrast, is located south-southwesterly. With superficial and less severe wind currents, it has lower quantities of pollens in comparison with the other two campuses (Fig 1, 5).

We suggest that studies such as the one being now presented should be conducted routinely to monitor changes in meteorological conditions, vegetation and cultivation areas. Some of the most central allergenic pollen grains, such as Pinaceae, *Salix* sp., Chenopodiaceae/ Amaranthaceae, Cupressaceae and Gramineae were found in high concentrations in the study area. These pollen types are responsible for many cases of pollinosis in the Mediterranean region and other parts of the world [1, 3, 6, 8, 11, 35, 38-41].

Pollens occurring in the air of the study area were determined and identified, the result of which being, a concept was formed in relation to the flora of this study area.

the aims of this study are to shed light on the systematic botany of Eskişehir and thus establish a pollen calendar for the city. The pollen calendar for campuses of Meselik, Yunus Emre and Iki Eylul, as well as for the city of Eskisehir, presented in this paper may be useful for allergologists in establishing a precise diagnosis and may help people suffering from allergic diseases.

REFERENCES

[1]. D'Amato , G., Spieksma, F Th M. 1990. Allergenic pollen in Europe, Grana, 30: 67-70.

[2]. Aytug, B. 1974. Pollen calendar for İstanbul, Turkey. Charpin J, Surinyach R. Atlas of European Allergenic Pollens. Paris: Sandoz Editions, 205-216.

[3]. Nilsson S, Palmberg-Gothard J. 1982. Pollen calendar for Huddinge (Sweden), 1973-1980. Grana, 21: 183-185.

[4]. Lejoly-Gabriel, M., Leuschner, R. M. 1983. Comparison of air-borne pollen at Louvain-la-Neuve (Belgium) and Basel (Switzerland) during 1979 and 1980, Grana 22: 59-64

[5]. Bousquet, J., Cour, P., Guerin, B., Michel, F.B. 1984. Allergy in the Mediterranean Area I. Polen Counts and Pollinosis of Montpellier. Clin. Allergy, 14: 249-258.

[6]. Koivikko A., Kupias R., Makinen Y., Pohjola A. 1986. Pollen seasons: Forecasts of the most important allergenic plants in Finland. Allergy, 41: 233-242.

[7]. Spieksma, F.Th. M., Frenguelli, G., Nikkels, A. H., Mincigrucci, G., Smithuis, L. O. M. J., Bricchi, E., Dankaart, W., Romano, B. 1989. Comparative study of airborne pollen concentrations in central Italy and The Netherlands (1982-1985) Emphasis on Alnus, Poaceae, and Artemisia. Grana, 28: 25-36.

[8]. Banik S, Chanda S, 1992. Airborne pollen survey of Central Calcutta, India in relation to college relation to allergy. Grana, 31: 72-75.

[9]. Inceoglu, O., P[illegible], N. M. , Şak[illegible], N., Sorkun, K. 1994. Airborne pollen concentration in Ankara, Turkey 1990-1993. Grana, 33: 158-161.

[10]. Bicakci, A., Inceoglu, O., Malyer, H., Sapan, N. 1996. Airborne Pollen Calendar of the Central Region of Bursa (Turkey). Aerobiologia, 12: 43-46.

[11]. B[illegible]c[illegible], Erken, S., Malyer, H. 1999. Airborne pollen grains of Eskişehir. 1st International Symposium on Protection of Natural Environment and Ehrami Karaçam, 315-322, Kütahya-Turkey.

[12]. D'Amato G, Spieksma F Th M, Liccardi G. 1998. Pollen related allergy in Europe. Allergy, 53: 567-578.

[13]. D'Amato G, Liccardi G. 2003. Allergenic pollen and urban air pollution in the mediterranean area. Allergy Clinical Immunol Inter, 15: 73-79.

[14]. Mc Donald, M.S. 1980. Correlation of airborne grass Pollen levels with meteorological data. Grana, 19: 53-56.

[15]. Spieksma, F.Th. M. 1990. Pollinosis in Europe: New observations and developments. Rev. Paleobot. Palynol., 64: 35-40.

[16]. Galan, C., Emberlin, J., Dominguez, E., Bryant, R. H., Villamados, F. 1995. A comparative analysis of daily variations in the Gramineae pollen counts at Cordoba, Spain. Grana, 34: 189:198.

[17]. Di-Giovanni, F., Kevan, P. G., Nasr, M. E. 1995. The variability in settling velocities of some pollen and spores. Grana, 34: 39-44.

[18]. Minero F J G, Morales J, Thomas C, Candau P. 1999. Relationship between air temperature and start of pollen emission in some arboreal taxa in South-western Spain. Grana, 38: 306-310.

[19]. Norris-Hill J. 1999. The diurnal variation of Poaceae pollen concentrations in rural area. Grana, 38: 301-305.

[20]. Ribeiro H, Cunha M, Abreu I. 2003. Airborne pollen concentration in the region of Braga, Portugal, and its relationship with meteorological parameters. Aerobiologia, 19: 21-27.

[21]. Anderson, J. H. 1985. Allergenic Airborne Pollen and Spores In Anchorage, Alaska. Ann.–Allergy, 54: 390-399.

[22]. Hansen B C S, Wright H E. 1987. The modern pollen rain of the North Dakota, U.S.A. Pollen Spores, 29: 167-184.

[23]. Davis, P.H. (Edt) 1965-1985. Flora of Turkey and The East Aegean Islands. Vol, 1-9, Edinburg University Press, Edinburgh.

[24]. Davis, P. H., Mill, R. R., Tan, K. (Edt.) 1988. Flora of Turkey and The East Aegean Islands (Supplement). Vol. 10, Edinburg University Press, Edinburgh.

[25]. Güner, A., Özhatay N., Ekim T., Başer KHC. (Edt.) 2000. Flora of Turkey and the East Aegean Islands. Vol. 11, Edinburg University Press, Edinburgh.

[26]. Ocak, A., Türe, C. 2001. The flora of the Meşelik campus of the Osmangazi university (Eskişehir-Turkey). The Herb-J Sist. Bot., 8 (2): 19-46.

[27]. Türe, C. and Böcük H. 2001. The Flora of the Anadolu University Campus (Eskişehir-Turkey). Anadolu University Journal of Science and Technology, (2): 83-95.

[28]. Yüce[illegible] E., 1992. Eskişehir'de Yetiştirilen Ağaç ve Çal[illegible]n Kentsel Ekoloji Aç[illegible]n Değerlendirilmesi (1). A. Ü. Fen Edebiyat Fak. Derg., IV, 1: 93-118.

[29]. Charpin, J., Suriyanch, R., Frankland A. W. 1974. Atlas of European Allergenic Pollens. Sandoz Editions, Paris.

[30]. Romano, B., Mincigrucci, G., Frenguelli, G., Bricchi, E. 1988. Airborne pollen content in the atmosphere of central Italy (1982-1986). Experientia, 44: 625-629.

[31]. Romano, B., Mincigrucci, G., Frenguelli, G., Bricchi, E., Murgia, M., Cresti, M., Dominicis, V.D. 1986. Pollen Concentrations in Central Italy (Ascoli Piceno and Siena). Grana, 25: 215-220.

[32]. Lewis V H, Vinay P. 1979. North American pollinosis due to insect pollinated plants. Ann Allergy, 42: 309-318.

[33]. Buck, P., Levetin, E., 1980, Hay Fever Plants in Oklohama. Ann. Allergy, 45: 2-32.

[34]. Eriksson, N.E., Wihl, J-A., Arrendal, H., Strandhede, S-O. 1984. Tree Pollen allergy. Allergy, 39: 610-617.

[35]. Bousquet, J., Hewitt B., Guerin, B., Dehivert H., Michel, F.B. 1986. Allergy in the Mediterranean Area II. Cross allergenicity among Urticaceae pollens (Parietaria and Urtica). Clin. Allergy, 16: 57-64.

[36]. Gioulekas, D., Chatzigeorgiou, G., Lylogiannis, S., Papakosta, D., Mpalafoutis, C., Spieksma, F.Th. M. 1991. Olea europea 3-year Pollen record in the area of Thessaloniki, Greece and its sensitizing significance. Aerobiologia, 7: 57-61.

[37]. Bousquet, J., Guerin, B., Hewitt B., Lim S., Michel, F.B. 1985. Allergy in the Mediterranean Area III. Cross reactivity among Oleaceae pollens. Clin. Allergy, 15: 439-448.

[38]. Jager S, Spieksma F Th M, Nolard N. 1991. Fluctations and trends in airborne concentrations of

some abundant pollen types, monitored at Vienna, Leiden and Brussels. Grana, 30: 309-312.

[39]. Kosiski S E, Carpenter G B. 1997. Predominant tree aerolallergens of the Washington, DC area: a six year survey (1989-1994). Ann Allergy Asthma Immunol, 78: 381-393.

[40]. Hallsdottir M. 1999. Birch pollen abundance in Reykjavik, Iceland. Grana, 38: 368-373.

[41]. Nitiu D S, Mallo C A. 2002. Incidence of allergenic pollen of Acer ssp., Fraxinus ssp., and Platanus spp., in the city of La Plata, Argentina: preliminary results. Aerobiologia, 18: 65-71.