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Research Article

Seasonal Variations of Airborne Pollen Grains in Karabük, Turkey

Karabük İli Hava Polenlerinin Mevsimsel Değişimleri

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Abstract

The concentrations of airborne pollen grains in Karabük atmosphere were analyzed during consecutive two years period (1 January 2006-31 December 2007). Pollen grains were sampled using two Durham samplers. In this study period, pollen grains belonging to 45 taxa were recorded. The total quantity of pollen grains were 3877±280.65/cm2 found in 2006, 4022±259.50/cm^2 were in 2007. From these, pollen grains of woody plants were recorded as 3515±225.53/cm^2 in 2006 and 3635±220.98/cm2 in 2007. Pollen grains of herbaceous plants were noted as 355±54.12/cm^2 in 2006 and 375±37.42/cm^2 in 2007. Pollen grains of bushy plants were found as 7±1/cm^2 in 2006 and 12±1.4/cm^2 in 2007. No statistically significant differences have been found between pollen counts from two samplers (t=0.0090-0.7818, p>0.05).

Pinus pollen grains were recorded highest level throughout two years. The other arboreal pollen types were *Fagus, Ostrya, Quercus, Pistacia, Cupressaceae/Taxaceae, Salix* and *Abies*. Gramineae, Brassicaceae and Chenopodiaceae/Amaranthaceae pollen were recorded highest level of herbaceous plants. Weekly concentrations of pollen grains have been displayed to connection of meteorological factors by Spearman Correlation Analysis. The two-year pollen calendar of Karabük atmosphere was prepared for pollen allergic patients.

Keywords: Karabük, Meteorological factors, Pollen, Turkey

Öz

Karabük atmosferinin polenleri 1 Ocak 2006-31 Aralık 2007 yılları arasında iki yıl boyunca incelendi. Pollenler iki durham aracı kullanılarak örneklendi. Çalışmada 45 taksona ait polen kaydedildi. Bir cm^2'ye düşen toplam polen sayısı 2006 yılında 3877±280.65, 2007 yılında ise 4022±259.50 olarak bulundu. Ağaç polenleri 2006 yılında cm^2 de 3515±225.53 adet, 2007 yılında 3635±220.98 adet saptandı. Otsu bitki polenleri 2006 yılında cm^2 de 355±54.12 adet, 2007 yılında 375±37.42 adet belirlendi. İki durham örnekleyicisi arasında polen sayısı bakımından istatistiksel olarak önemli bir fark bulunmadı (t=0.0090-0.7818, p>0.05).

Pinus polenleri iki yıl boyunca en yüksek miktarda görülen polen olarak kaydedildi. Diğer ağaç polenleri ise *Fagus, Ostrya, Quercus, Pistacia, Cupressaceae/Taxaceae, Salix* ve *Abies*'tir. en fazla görülen otsu bitki polenleri ise Gramineae, Brassicaceae and Chenopodiaceae/Amaranthaceae polenleri olarak belirlendi. Polenlerin haftalık konsantrasyonlarının Meteorolojik faktörler ile ilişkisi Spearman Korelasyon Analizi ile belirlendi. Polen alerjik hastalar için Karabük atmosferinin iki yıllık polen takvimi hazırlandı.

Anahtar Kelimeler: Karabük, Meteorolojik factörler, Polen, Türkiye

1. Introduction

Atmospheric pollen is a major cause of allergies, historically known as "hay fever" (Molina et al. 2001, Rodriguez-Rajo et al. 2003, Porsbjerg et al. 2003, Sin et al. 2007). During the last quarter of the 20th century, an increase in the incidence of pollen allergy in most European countries and that this trend is particularly noticeable in urban areas (D'Amato and Spieksma 1995, Leuschner et al. 2000). Pollen allergies are mainly caused by *Betula* pollen in North Europe (Speiksma et al. 1995, Latalowa et al. 2002, Porsberg et al. 2003), by the pollen of Gramineae followed by *Betula* pollen in central Europe (Rodriguez-Rajo 2003), by the pollen of Gramineae and *Parietaria* in South Europe (Speiksma et al. 1985, D'Amato and Liccardi 2003, Rodriguez-Rajo 2003, Syrigou et al. 2003).

In each geographical area, there is a succession of different flowering species throughout the year, following a rhythm mainly established by meteorological parameters. Such

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conditions influence both the ontogeny of pollen grains and their dispersion (Molina et al. 2001, Rodrigues-Rajo 2003, Boyacioğlu et al. 2007, Potoğlu Erkara 2008).

In Turkey, aeropalynological studies are gradually gaining more importance from year to year (Karamanoğlu and Özkaragöz 1968, Aytuğ 1974, Yurdukoru 1979, İnceoğlu et al. 1994, Özler and Pehlivan 1995, Bicakci et al. 1996, Bicakci et al. 1999, Pınar et al. 1999, Bicakci et al. 2000a,b,c, 2002, Güvensen and Öztürk 2002, Kaplan 2004, Kaya and Aras 2004, Türe and Salkurt 2005, Potoğlu Erkara et al. 2007, Toraman 2007, Boyacıoğlu et al. 2007, Ayvaz et al. 2008, Türe and Böcük 2009, Bılışık et al. 2008, Kızılpınar and Doğan 2010, Çeter et al. 2012, Kaplan and Serbes 2014).

The aim of this study was to identify pollen grains in Karabük city, pollen season periods and pollen concentrations. The two-year pollen calendar was prepared. This study will be contributed to airborne pollen flora of Black Sea Region in Turkey.

2. Materials and Methods

Karabük city is situated at 41° 34' N, 33° 06' E Northwest of Turkey at an altitude 400m. above sea level. Karabük has a Temperate, Irano-Turanian vegetation, and generally follows a typical semi-arid Mediterranean climate. According to Emberger's bioclimate essentials,

Karabük city center is under the influence of semi-arid upper cold Mediterranean bioclimate level (Akman 2011). During the sampling period the highest temperature was seen in August, the minimal precipitation was seen in July and August (Fig. 1). The annual average rainfall for the period 1975-2007 was 487.95 mm. Seasonal Rainfall regime is East Mediterraean Type I (WSAS). Meteorological data have been obtained from Government Meteorological Institute.

In order to identify types and levels of airborne pollen and spore concentration in the atmosphere of Karabük by gravimetric method in 2006 and 2007, two Durham samplers were situated on roof and garden University of Karabük, Faculty of Technical Education of Karabük. Weekly pollen slides were inserted on the Durham samplers and mounted in safranin-glycerine jelly (Woodehouse 1965). Nikon Eclipse 200 trinocular investigation microscope was used for the identification, count and photography of the pollen. Counting was made on a 24x50 mm (12 cm^2) area of the slide, which was calculated on 1 cm^2 bases (Charpin and Surinyach 1974, Bıçakcı et al. 2000c). Some pollen morphology book (Pehlivan 1995, Smith 2002, Sin et al. 2007) and reference pollen preparations of the local plants were utilized during the identification of the pollen types.

According to pollen counts, unpaired t test was made between two samplers using Graphpad on line calculator (graphpad.com) and no statistically significant differences were found (t=0.0090-0.7818, p>0.05). Therefore only annual mean pollen quantities and standart deviations were calculated. For relationship between spore concentrations and meteorological parameters Spearman Rank Correlation analysis were made by using SPSS 19.0 program. Monthly variations of meteorological factors and concentrations of total pollen/cm^2 were shown in Figure 1.

3. Results

Total 7899±545.01 pollen/cm^2 belonging to 42 pollen types has been detected in Karabük atmosphere. Of these, 3877±242.40 pollen/cm^2 was found in 2006, 4022±229.5 pollen/cm^2 in 2007 (Table 1-4). The percentage of total arboreal pollen was 90.52% and nonarboreal was 9.48%. The most frequent taxa as follows; *Pinus* 46.84%, *Fagus* 13.20%, *Ostrya* 6.01%, *Quercus* 5.89%, *Pistacia* 3.90%, Gramineae 2.57%, Brassicaceae 2.56%, Cupressaceae/Taxaceae 2.15%, *Salix* 2.08% and *Abies* 1.96% in two years (Tables 3, 4).

The highest total monthly pollen concentrations were in May in both 2006 and 2007 (Tables 1-3).

Monthly variations of total pollen grains recorded in the atmosphere of Karabük have been shown in Fig. 1. The types of pollen present in the atmosphere of Karabük have been shown in Figs. 2, 3 and in the form of a pollen calendar in Fig. 4 based on the counts in 2006-2007.

The earliest pollen grains in the atmosphere of Karabük appeared in January. *Corylus* and *Pinus* pollen observed in this month. Pollen grains started to increase in March and April, and reached their maximum levels in June 2006 (37.17%), in May 2007 (%73.47) (Tables 1-2).

The two years distributions of nine dominant taxa were given below;

Pinus: The highest amount was observed 1337±14.85 pollen/cm^2 in June 2006, 1605±14.14 pollen/cm^2 in May 2007. The two years total was found as 3700±99.97 pollen/cm^2 (Tables 1-3, 2, 3, Figs. 2-4).

Fagus: Pollen season has started beginning of April, ended in the first week of June (Figs 2, 4). The highest concentrations were seen in May, 272±13.44 pollen/cm^2 in 2006, 463±16.97

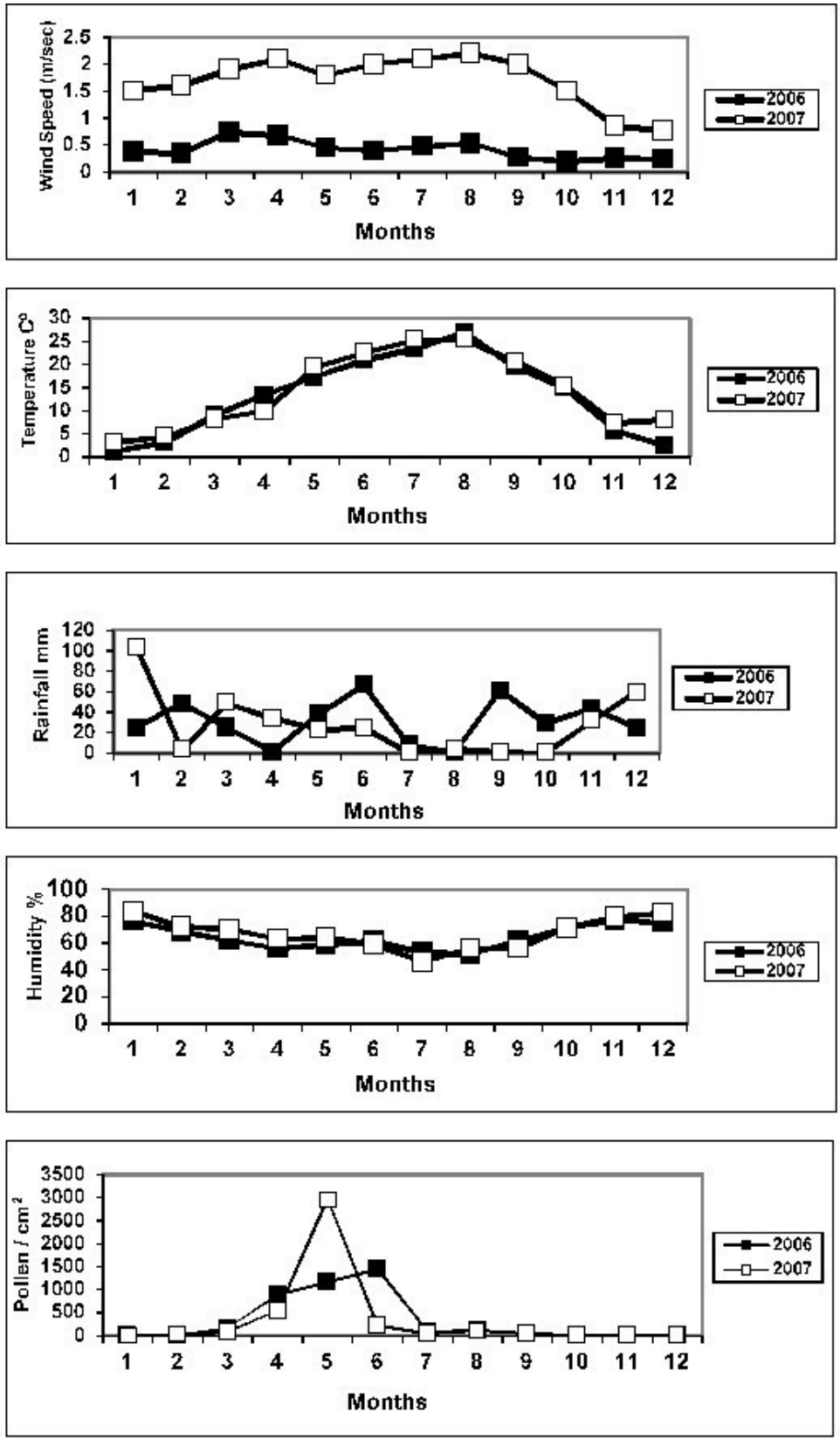

Figure 1. Monthly variations of meteorological factors and concentrations of total pollen/cm^2 (2006-2007).

Table 1. Monthly pollen counts and percentage of monthly pollen season in 2006.

Pollen Types	1	2	3	4	5	6	7	8	9	10	11	12	Total	SD	%
Pinus	1	0	2	21	491	1337	14	10	3	2	2	1	1884	76,54	**48,59**
Fagus	0	0	0	198	272	1	0	0	0	0	0	0	471	31,07	**12,15**
Ostrya	0	0	13	210	24	1	0	0	0	0	0	0	248	13,42	**6,40**
Quercus	0	0	0	77	158	1	0	0	0	0	0	0	236	30,4	**6,09**
Pistacia	0	0	0	84	56	1	0	0	0	0	0	0	141	4,95	**3,64**
Cupress./Taxa.	0	0	3	78	6	1	0	2	0	0	0	0	90	11,92	**2,32**
Salix	0	0	0	41	40	0	0	0	0	0	0	0	81	16,27	**2,09**
Abies	0	0	0	10	28	28	0	0	0	0	0	0	66	2,82	**1,70**
Carpinus	0	0	5	40	5	0	0	0	0	0	0	0	50	5,65	**1,29**
Juglans	0	0	0	37	6	0	0	0	0	0	0	0	43	4,24	**1,11**
Phyllirea	0	0	0	6	35	0	0	0	0	0	0	0	41	2,82	**1,06**
Platanus	0	0	6	21	2	0	0	0	0	0	0	0	29	4,94	**0,75**
Populus	0	0	17	7	0	0	0	0	0	0	0	0	24	0	**0,62**
Corylus	0	7	15	0	0	0	0	0	0	0	0	0	22	0,7	**0,57**
Tilia	0	0	0	0	0	9	8	0	0	0	0	0	17	3,54	**0,44**
Castanea	0	0	0	0	0	9	7	0	0	0	0	0	16	3,54	**0,41**
Fraxinus	0	0	15	1	0	0	0	0	0	0	0	0	16	4,24	**0,41**
Morus	0	0	0	6	9	0	0	0	0	0	0	0	15	1,4	**0,39**
Alnus	0	6	6	0	0	0	0	0	0	0	0	0	12	3,54	**0,31**
Robinia	0	0	0	0	9	1	0	0	0	0	0	0	10	3,54	**0,26**
Ulmus	0	0	2	0	0	0	0	0	0	0	0	0	2	0	**0,05**
Acer	0	0	0	1	0	0	0	0	0	0	0	0	1	0	**0,03**
ARBOREAL	1	14	83	838	1141	1389	29	12	3	2	2	1	3515	230,39	**90,66**
%	0,03	0,40	2,36	23,84	32,46	39,52	0,83	0,34	0,09	0,06	0,06	0,03	**100**		
Brassicaceae	0	0	81	19	0	0	0	0	0	0	0	0	100	12,1	**2,58**
Gramineae	0	0	0	0	7	39	19	25	1	0	0	0	91	22,63	**2,35**
Chenop./ Amarant.	0	0	0	0	0	3	20	27	13	3	1	1	68	10,99	**1,75**
Cichoroideae	0	0	0	0	0	2	2	1	13	0	0	0	18	0	**0,46**
Delphinium	0	0	0	0	0	0	7	5	0	0	0	0	12	1,4	**0,31**
Artemisia	0	0	0	0	0	0	4	8	0	0	0	0	12	0,7	**0,31**
Ambrosia	0	0	0	0	0	0		9	0	0	0	0	9	1,4	**0,23**
Xantihum	0	0	0	0	0	0		6	2	0	0	0	8	0	**0,21**
Umbelliferae	0	0	0	0	0	0	3	5	0	0	0	0	8	0	**0,21**
Asteroideae	0	0	0	0	0	4		1	0	0	0	0	5	2,1	**0,13**
Plantago	0	0	0	1	0	0	3	0	0	0	0	0	4	0	**0,10**
Rumex	0	0	0	0	0	2	2	0	0	0	0	0	4	1,4	**0,10**
Rosa	0	0	0	3	1	0	0	0	0	0	0	0	4	0,5	**0,10**
Urticaceae	0	0	0	2	0	2	0	0	0	0	0	0	4	0,7	**0,10**

Table 1. Cont.

Erica	0	0	0	3	0	0	0	0	0	0	0	0	3	0,5	**0,08**
Centaurea	0	0	0	0	0	0	1	2	0	0	0	0	3	0,7	**0,08**
Campanulaceae	0	0	0	0	0	0	1	2	0	0	0	0	3	0	**0,08**
Fabaceae	0	0	0	0	0	0	1	2	0	0	0	0	3	0	**0,08**
Euphobiaceae	0	0	0	1	1	0	0	0	0	0	0	0	2	0	**0,05**
Boraginaceae	0	0	0	1	0	0	0	0	0	0	0	0	1	0	**0,03**
NON-ARBOREAL	0	0	81	30	9	52	63	93	29	3	1	1	362	12,1	**9,34**
Monthly total %	0	0	22,4	0,8	0,2	14,4	17,4	25,7	8,0	1,4	0,8	0,6	**100**		
Monthly Total Pollen	**1**	**14**	**164**	**868**	**1150**	**1441**	**92**	**105**	**32**	**5**	**3**	**2**	**3877**	**242,40**	**100**
Monthly Total %	**0,03**	**0,36**	**4,23**	**22,39**	**29,66**	**37,17**	**2,37**	**2,71**	**0,83**	**0,13**	**0,08**	**0,05**	**100**		

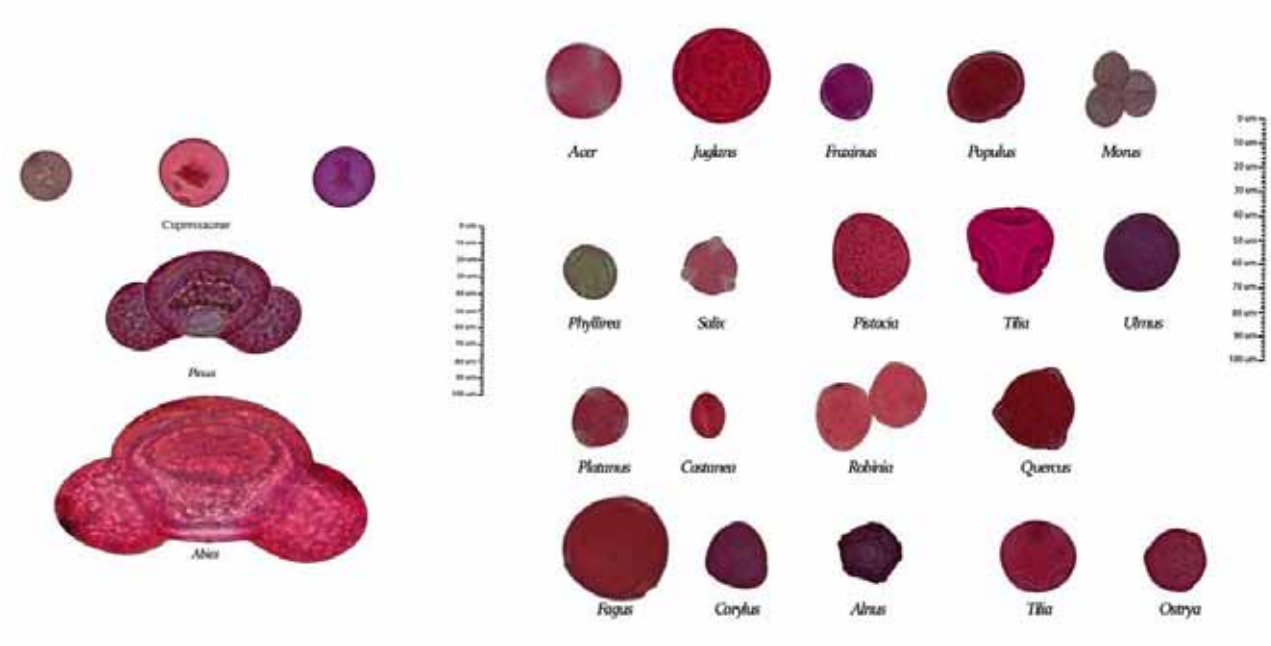

Figure 2. Arboreal Pollen grains in Karabük atmosphere (2006-2007).

pollen/cm^2 in 2007. Total amount was 1043±68.5 pollen/cm^2 in two years (Tables 1-3).

Ostrya: Two years total was recorded 475±36.03 pollen/cm^2. The highest counts were 210±33.94 pollen/cm^2 in April 2006, 117.5±33.23 pollen/cm^2 in May 2007. Pollen season continued 11 weeks (Figures 2, 4).

Quercus: Mountly highest quantity was achieved in May both in 2006 and 2007 (158±3.54 spore/cm^2 in 2006, 212±28.28 spore/cm^2 in 2007, respectively) (Tables 1-3). Pollen season was ten weeks (Figures 2, 4).

Pistacia: Pollen season started from April ended first week of June. The highest abundance was recorded in April both in 2006 (84±2.81pollen/cm^2) and 2007 (95±6.36 pollen/cm^2) (Tables 1-3, Figures 2, 4).

Gramineae: Monthly highest concentration was found in June 2006 (64±6.36 pollen/cm^2) and 2007 (39±6.36 pollen/

Table 2. Monthly pollen counts and percentage of monthly pollen season in 2007.

Pollen Type	1	2	3	4	5	6	7	8	9	10	11	12	Total	SD	%
Pinus	1	2	1	6	1605	168	12	14	4	1	1	1	1816	23,43	45,15
Fagus	0	0	0	109	463	0	0	0	0	0	0	0	572	37,43	14,22
Quercus	0	0	1	15	212	1	0	0	0	0	0	0	229	21,18	5,69
Ostrya	0	0	3	106	117	1	0	0	0	0	0	0	227	22,61	5,64
Pistacia	0	0	0	95	72	0	0	0	0	0	0	0	167	24,05	4,15
Abies	0	0	0	5	78	6	0	0	0	0	0	0	89	4,2	2,21
Salix	0	0	1	15	67	0	0	0	0	0	0	0	83	18,3	2,06
Cupress./Taxa.	0	0	0	20	60	0	0	0	0	0	0	0	80	16,92	1,99
Carpinus	0	0	5	44	16	0	0	0	0	0	0	0	65	4,92	1,62
Robinia	0	0	1	0	62	0	0	0	0	0	0	0	63	0,7	1,57
Juglans	0	0	0	4	36	0	0	0	0	0	0	0	40	2,8	0,99
Platanus	0	0	0	22	13	0	0	0	0	0	0	0	35	7,1	0,87
Populus	0	0	15	20	0	0	0	0	0	0	0	0	35	11,24	0,87
Phyllirea	0	0	0	7	26	0	0	0	0	0	0	0	33	7	0,82
Morus	0	0	0	1	22	0	0	0	0	0	0	0	23	0,7	0,57
Corylus	1	10	9	0	0	0	0	0	0	0	0	0	20	6,2	0,50
Alnus	0	8	7	0	0	0	0	0	0	0	0	0	15	0,7	0,37
Tilia	0	0	0	0	0	8	7	0	0	0	0	0	15	0	0,37
Castanea	0	0	0	0	7	7	0	0	0	0	0	0	14	5,6	0,35
Fraxinus	0	5	6	0	0	0	0	0	0	0	0	0	11	4,9	0,27
Acer	0	0	0	2	0	0	0	0	0	0	0	0	2	0,7	0,05
Ulmus	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0,02
ARBOREAL	2	25	49	472	2856	191	19	14	4	1	1	1	3635	220,98	90,38
Monthly Arboreal %	0,06	0,69	1,35	12,98	78,57	5,25	0,52	0,39	0,11	0,03	0,03	0,03			
Gramineae	0	0	0	3	64	22	8	12	3	0	0	0	112	11,24	2,78
Brassicaceae	0	0	34	61	7	0	0	0	0	0	0	0	102	14,14	2,54
Chenop./ Amarant.	0	0	0	0	1	5	4	27	17	2	1	1	58	0,7	1,44
Xanthium	0	0	0	0	0	0	0	7	10	0	0	0	17	3,52	0,42
Ambrosia	0	0	0	0	0	0	0	13	1	0	0	0	14	2,12	0,35
Delphinium	0	0	0	0	0	0	0	13	0	0	0	0	13	1,2	0,32
Rumex	0	0	0	9	2	0	0	0	0	0	0	0	11	0,7	0,27
Umbelliferae	0	0	0	0	2	0	6	3	0	0	0	0	11	0,7	0,27
Asteroideae	0	0	0	1	8	0	0	0	0	0	0	0	9	0,7	0,22
Rosaceae	0	0	0	2	7	0	0	0	0	0	0	0	9	0,7	0,22
Artemisia	0	0	0	0	0	0	0	2	5	0	0	0	7	0,7	0,17
Fabaceae	0	0	0	0	2	0	2	1	0	0	0	0	5	0	0,12
Centaurea	0	0	0	0	0	0	3	1	0	0	0	0	4	1,4	0,10
Urticaceae	0	0	0	1	1	0	2	0	0	0	0	0	4	0	0,10

Table 2. Continued

Erica		0	0	2	1	0	0	0	0	0	0	0	3	0,7	0,07
Campanulaceae	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0,05
Plantago	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0,05
Cichoroideae	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0,05
Boraginaceae	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0,02
Euphorbiaceae	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0,02
Total NAP	0	0	34	79	99	27	25	81	38	2	1	1	387	38,52	9,62
Monthly Total NAP %			8,79	20,41	25,58	6,98	6,46	20,93	9,82	0,52	0,26	0,26			
Monthly Total Pollen	**2**	**25**	**83**	**551**	**2955**	**218**	**44**	**95**	**42**	**3**	**2**	**2**	**4022**	**259,5**	**100**
Monthly Total %	0,05	0,62	2,06	13,70	73,47	5,42	1,09	2,36	1,04	0,07	0,05	0,05	**100**		

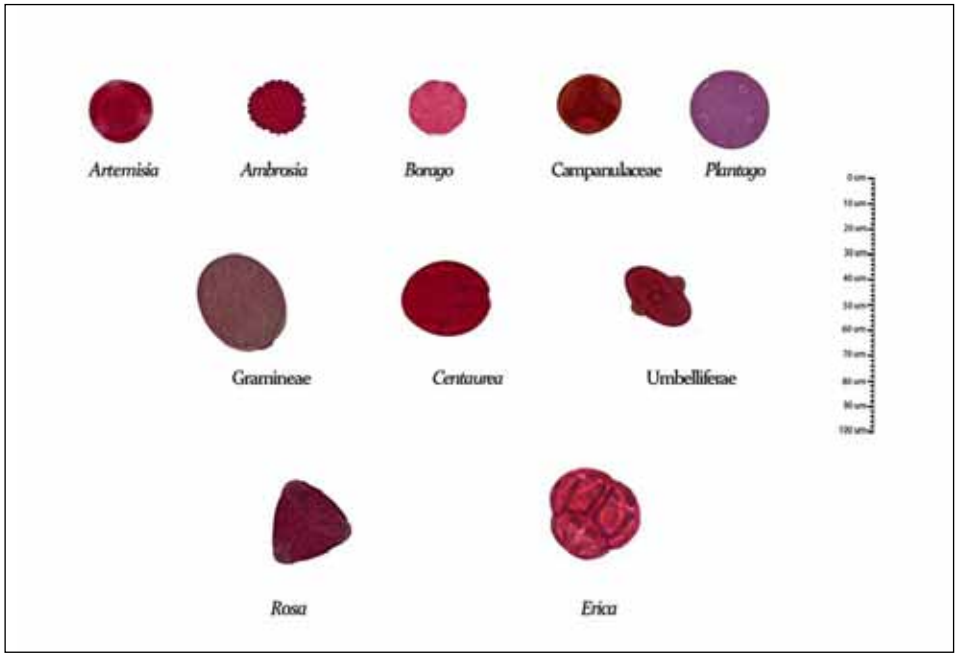

Figure 3. Nonarboreal pollen grains in Karabük atmosphere (2006-2007).

cm²). Pollen season continued 23 weeks (Tables 1-3, Figures 3,4).

Cruciferae: The highest counts were 81±33.94 pollen/cm²in March 2006, 61±33.94 pollen/cm² in April 2007 (Tables 1-3).

Cupressaceae/Taxaceae: Monthly highest quantity was recorded in April 2006 (67±2.81pollen/cm²) and May 2007 (60±2.81pollen/cm²). Pollen season continued 10 weeks (Tables 1-3, Figures 2, 4).

Salix: Pollen season started from last week of March ended the third week of May (Figures 2,4). The highest concentration was observed in April 2006 (78±2.81pollen/cm²) and 2007 (41±2.81 pollen/cm²) (Tables 1-3).

Abies: The highest amount was found in May and June 2006 (28±2.81pollen/cm²) June 2007 (78±2.81pollen/cm²) (Tables 1-3). Pollen season was 12 week (Figures 2, 4).

Over the 2-year study period, pollen grains from trees were dominant (90.52%) in the atmosphere of Karabük. The frequency of arboreal pollen grains generally depends on

distribution of the local vegetation and rate of the pollen production. Same results are also found in other studies caried out in Turkey, Ankara (76%) (İnceoğlu et al. 1994), Balıkesir (70.92%) (Bicakci and Akyalcin 2000), Isparta (71%) (Bıçakcı et al. 2000), Zonguldak 94% (Kaplan 2004), Yalova (80.50%) (Altunoğlu et al. 2004), Bartın (72.8 %) (Kaya and Aras 2004), (69 %) (Özveren 2005), Eskişehir (81%) (Potoğlu Erkara et al. 2007), Trabzon (59.2%) (Ayvaz et al. 2008), Bilecik (75.74%) (Türe and Böcük 2009), Tekirdağ (64 %) (Erkan et al. 2010), İstanbul (80%) (Celenk et al. 2010), Çamkoru-Ankara (92.6%) (İlginç and

Doğan 2010), Kastamonu (85.4%) (Çeter et al. 2012), Düzce (66.60 %) (Serbes and Kaplan 2014).

When the main pollination period of the various types determined in Karabük is considered, it can be seen that three groups can be distiguished: (1) polen with a short principal period <10 weeks: *Fagus, Salix, Populus, Juglans, Carpinus, Alnus, Corylus, Acer, Castanea, Ulmus*, *Morus, Platanus, Tilia, Phyllirea, Pistacia, Robinia, Ambrosia, Centaurea*, Boraginaceae, Campanulaceae, Euphorbiaceae, Urticaceae, Brassicaceae, *Xanthium, Rumex,* Umbelliferae, Fabaceae, Cichoroideae, Asteroideae, *Delphinium, Rosa, Erica* and *Plantago*; (2) pollen with a medium principal period, between 10 and 17 weeks: *Quercus, Ostrya*, Cupressaceae/Taxaceae, *Abies* and *Artemisia*; (3) pollen with a long principal period >17 weeks: *Pinus,* Chenopodiaceae/ Amaranthaceae and Gramineae (Figure 4). Same results have been found in Zonguldak (Kaplan 2004) and Bilecik (Türe and Böcük 2009).

Table 3. Total monthly concentrations of arboreal (AP) pollen grains in two years study period.

Pollen Types	1	2	3	4	5	6	7	8	9	10	11	12	Total	SD	Total %
Pinus	2	2	3	27	2096	1505	26	24	7	3	3	2	3700	99,97	46,84
Fagus	0	0	0	307	735	1	0	0	0	0	0	0	1043	68,5	13,20
Ostrya	0	0	16	316	141	2	0	0	0	0	0	0	475	36,03	6,01
Quercus	0	0	1	92	370	2	0	0	0	0	0	0	465	51,58	5,89
Pistacia	0	0	0	179	128	1	0	0	0	0	0	0	308	29	3,90
Cupress./Taxa.	0	0	3	98	66	1	0	2	0	0	0	0	170	28,13	2,15
Salix	0	0	1	56	107	0	0	0	0	0	0	0	164	34,57	2,08
Abies	0	0	0	15	106	34	0	0	0	0	0	0	155	7,02	1,96
Carpinus	0	0	10	84	21	0	0	0	0	0	0	0	115	10,57	1,46
Juglans	0	0	0	41	42	0	0	0	0	0	0	0	83	7,04	1,05
Phyllirea	0	0	0	13	61	0	0	0	0	0	0	0	74	9,82	0,94
Robinia	0	0	1	0	71	1	0	0	0	0	0	0	73	4,24	0,92
Platanus	0	0	6	43	15	0	0	0	0	0	0	0	64	12,04	0,81
Populus	0	0	32	27	0	0	0	0	0	0	0	0	59	11,24	0,75
Morus	0	0	0	7	31	0	0	0	0	0	0	0	38	2,1	0,48
Corylus	1	17	24	0	0	0	0	0	0	0	0	0	42	6,9	0,53
Alnus	0	14	13	0	0	0	0	0	0	0	0	0	27	4,24	0,34
Tilia	0	0	0	0	0	17	15	0	0	0	0	0	32	3,54	0,41
Castanea	0	0	0	0	7	16	7	0	0	0	0	0	30	9,14	0,38
Fraxinus	0	5	21	1	0	0	0	0	0	0	0	0	27	9,14	0,34
Acer	0	0	0	3	0	0	0	0	0	0	0	0	3	0,7	0,04
Ulmus	0	0	2	1	0	0	0	0	0	0	0	0	3	0	0,03
Total AP	3	39	132	1310	3997	1580	48	26	7	3	3	2	7150	451,37	**90,52**
Monthly Total AP %	0,04	0,53	1,85	18,31	55,92	22,10	0,67	0,36	0,10	0,04	0,04	0,03	100		

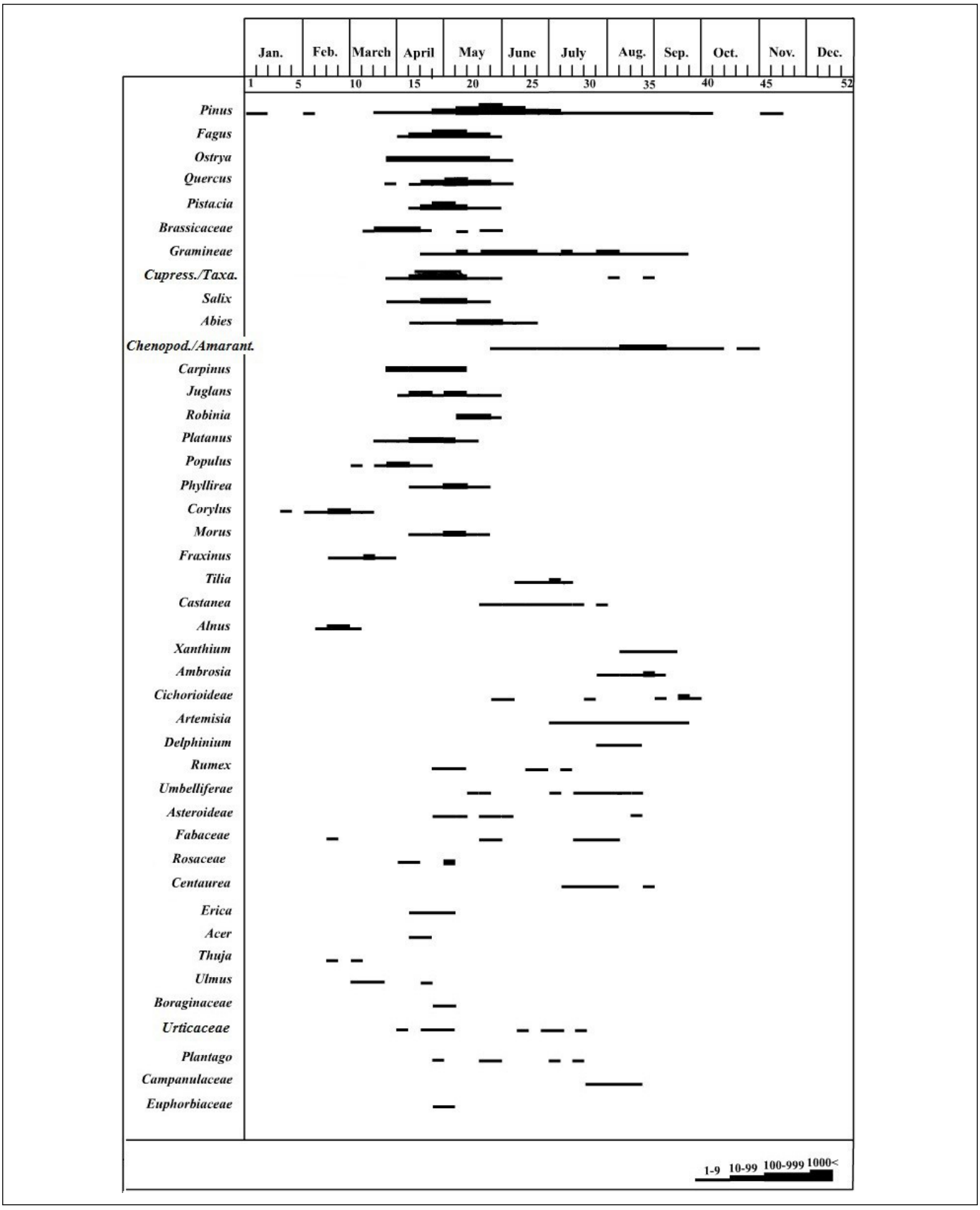

Figure 4. Pollen calendar of Karabük.

Table 4. Two years monthly concentrations of nonarboreal (NAP) and total pollen (AP+NAP) grains.

Pollen Types	1	2	3	4	5	6	7	8	9	10	11	12	Total	SD	%
Gramineae	0	0	0	3	71	61	27	37	4	0	0	0	203	33,87	2,57
Brassiceaceae	0	0	115	80	7	0	0	0	0	0	0	0	202	36,77	2,56
Chenop./ Amarant.	0	0	0	0	1	8	24	54	30	5	2	2	126	11,69	1,60
Delphinium	0	0	0	0	0	0	7	18	0	0	0	0	25	2,6	0,32
Xanthium	0	0	0	0	0	0	0	13	12	0	0	0	25	3,52	0,32
Ambrosia	0	0	0	0	0	0	0	22	1	0	0	0	23	3,52	0,29
Cichoroideae	0	0	0	0	0	2	2	1	15	0	0	0	20	0	0,03
Artemisia	0	0	0	0	0	0	4	10	5	0	0	0	19	1,4	0,24
Umbelliferae	0	0	0	0	2	0	9	8	0	0	0	0	19	0,7	0,24
Rumex	0	0	0	9	2	2	2	0	0	0	0	0	15	2,1	0,19
Rosaceae	0	0	0	5	8	0	0	0	0	0	0	0	13	1,2	0,16
Asteroideae	0	0	0	1	8	4	0	1	0	0	0	0	14	2,8	0,18
Fabaceae	0	0	0	0	2	0	3	3	0	0	0	0	8	0	0,10
Urticaceae	0	0	0	3	1	2	2	0	0	0	0	0	8	0,7	0,10
Centaurea	0	0	0	0	0	0	4	3	0	0	0	0	7	2,1	0,09
Plantago	0	0	0	1	2	0	3	0	0	0	0	0	6	0	0,08
Erica	0	0	0	5	1	0	0	0	0	0	0	0	6	1,2	0,08
Campanulaceae	0	0	0	0	0	0	1	4	0	0	0	0	5	0	0,06
Boraginaceae	0	0	0	1	2	0	0	0	0	0	0	0	3	0	0,04
Euphorbiaceae	0	0	0	1	1	0	0	0	0	0	0	0	2	0	0,03
Nonarboreal	0	0	115	109	108	79	88	174	67	5	2	2	749	93,64	9,48
Monthly NAP %	0	0	1,46	1,38	1,37	1,00	1,11	2,20	0,85	0,06	0,03	0,03	9.48		
Total (AP+NAP)	3	39	247	1419	4105	1659	136	200	74	8	5	4	7899	545,01	100
Monthly Total (AP+NAP) %	0,04	0,05	3,13	17,96	51,97	21,00	1,72	2,53	0,94	0,14	0,06	0,05	100		

Table 5. The results of Spearman's correlation analysis between monthly pollen counts and meteorological factors in 2006 and 2007.

Correlations	Relative Humidity (%)		Rainfall (mm)		Wind speed (m/sn)		Mean Temperature (C°)	
	2006	2007	2006	2007	2006	2007	2006	2007
Total Pollen	-0.737**	-0.001	-0.229	0.193	0.513**	0.574**	0.609**	0.426**
Total Arboreal	-0.690**	0.048	-0.226	0.287	0.542**	0.673**	0.467**	0.247
Total None-Arboreal	-0.642**	-0.199	-0.192	0.088	0.423**	0.331*	0.762**	0.644**
Pinus	-0.696**	-0.223	-0.221	0.150	0.276	0.413*	0.713**	0.572**
Fagus	-0.124	0.086	-0.055	0.204	0.112	0.395**	0.103	-0.047
Ostrya	-0.325*	0.095	-0.234	0.244	0.317*	0.492**	0.106	0.045
Quercus	-0.312*	0.060	-0.104	0.188	0.053	0.487**	0.151	0.028
Brassicaceae	-0.224	0.092	-0.171	0.254	0.506**	-0.150	-0.079	0.841**
Chenopodiaceae	-0.346*	-0.337*	-0.066	-0.229	0.104	0.299*	0.763**	0.625**
Gramineae	-0.608**	-0.270	-0.170	0.208	0.136	0.492**	0.790**	-0.045

** Correlation is statistically significant at 0.05 level. ** Correlation is statistically significant at 0.01 level.*

Monthly pollen concentrations of seven most frequently recorded taxa were entered into Spearman's correlation analysis with corresponding meteorological factors (Table 5). In general, it was shown that increases in the wind speed and mean temperature were related to increases monthly pollen concentrations, whereas increases the relative humidity and rainfall had an opposite effect on monthly pollen concentrations and caused them to decrease. Similar results have been found by Stach et al. (2008), Çeter et al. (2012).

There were significant positive correlations between total pollen counts and mean temperature and wind speed in 2006 and 2007 (Table 5).

Total monthly pollen counts were negatively corelated with monthly relative humidty in 2006. *Pinus* pollen counts were negatively correlated with relative humidity in 2006, positively correlated with wind speed in 2006, mean temperature in 2006 and 2007. Fagus pollen counts showed only strong positive correlation with wind speed in 2007.

Ostrya pollen counts were positively correlated with wind speed in 2006 and 2007, negatively correlated with relative humidity in 2006.

Quercus pollen counts showed negatively correlation with relative humidity in 2006, positively correlation with wind speed in 2007.

Monthly Cruciferae pollen counts were positively correlated with wind speed in 2006 and mean temperature in 2007.

Chenopodiaceae pollen concentrations showed strong negative correlation with relative humidity, positive correlation with mean temperature in both years (Table 5).

Monthly Poaceae pollen counts were positively correlated with wind speed and mean temperature. Çeter et al. (2012) have found same relationship for wind speed but an opposite relationship for mean temperature and Gramineae pollen concentrations in Kastamonu.

4. Discussion

The two year pollen calendar showing weekly pollen counts will help pollen allergenic people and allergy doctors.

Monthly daily temperature, relative humidity and wind speed found to significantly affect atmospheric pollen counts from selected taxa, but the relationships between pollen counts and meteorological parameters can vary from different pollen types and from year to year, and so there is a need for more studies of this subject.

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