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SURVEY OF AIRBORNE POLLEN IN SHIRAZ, IRAN DURING 2012

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Abstract

Airborne pollen grains in the atmosphere are important aeroallergens that can lead to allergic diseases in susceptible people. The determination of pollen type and quantity not only presents botanists with valuable information about vegetation of the area under study, but also provides allergologists with tools for accurate diagnosis and proper medical treatment. An aerobiological survey was carried out in the atmosphere of the city of Shiraz, Iran, by means of a Hirst type volumetric sampler, from January 1st to December 31st 2012. A total of 12270 pollen grains belonging to 11 taxa were identified and recorded, of which 82.44% were tree or shrub, 7.24% herbaceous and 10.32% grass type. The majority of the investigated pollen grains were from *Pinus* sp., *Buxus* sp., Cupressaceae, *Fraxinus* sp. and Poaceae. The pollen count reached its highest levels in March and April, and its lowest levels in July and December. A correlation analysis was established between monthly pollen type and count, and some meteorological parameters. This aerobiological survey shows the existence of, and seasonal variation of different types of pollen grains in the atmosphere of Shiraz. The results of the survey may help allergologists with the diagnosis and treatment of airborne allergies due to pollen grains.

Key words: Airborne pollen, Shiraz, Meteorological parameters, Allergy

Introduction

Pollen grain is the male gametophyte in the life cycle of seed plants, with an important role in sexual reproduction. Most airborne pollens released into the atmosphere during pollination are known aeroallergens. These foreign particles are recognized by the immune system and lead to allergic symptoms that affect the patients' quality of life (D'Amato *et al*., 2010; Sofiev & Bergmann, 2012; Songnuan, 2013). Therefore, pollen identification and characterization is of great importance, especially in populated areas, and allergologists must be informed of the time and concentration of pollen production for prevention and therapy of pollen-related allergic diseases.

Climate changes, including global warming, have a significant impact on atmospheric pollen grains by increasing their amount and growth rate, the amount of allergenic proteins in each pollen and the pollen season time and duration (D'Amato *et al*., 2013; Songnuan, 2013). In spite of genetic and physiological control of pollen production, the critical role of environmental factors has been proven. Meteorological variables such as temperature, relative humidity, rainfall, light intensity and wind speed and direction can be impacted on pollen release, transport and dispersal and therefore on air concentration of pollen grains (Kasprzyk & Walanus, 2010; Aboulaich *et al*., 2013). Few investigations have been conducted on the airborne pollen grains in Iran, compared with other countries. Amin & Bokhari (1977) first registered atmospheric pollen grains in Shiraz. Earlier on, an airborne pollen survey had also been carried out in Tehran by Kimiayi (1970) and Shafiee (1976). Clinical studies in relation to allergenic pollens have been performed in various cities of Iran including Shiraz (Kashef *et al*., 2003), Tehran (Kimiayi, 1970; Shafiee, 1976), Karaj (Farhoudi *et al*., 2005), Mashhad (Fereidouni *et al*., 2009) and Ahvaz (Assarehzadegan *et al*., 2013). However, the effect of environmental parameters on pollen characteristics has not been reported from Iran thus far.

The aim of this work is to document daily and monthly pollen counts, to list types of pollen and to correlate them with some meteorological parameters in the atmosphere of Shiraz, during 2012.

Materials and Methods

This study was performed in Shiraz, the capital city of Fars province. This city (29.37º N, 52.32º E) is located in southwest of Iran in the green plain at the Zagros Mountains at an altitude of 1486 meters above sea level, with a total surface area of 240 km^2 and a population of 1,700,687. Shiraz is known for its many famous gardens, and has a moderate climate with four distinct seasons. This area has an average annual rainfall of 424.8 mm and the mean annual temperature of 18.3ºC (Table 1).

Sampling was conducted from January 1st to December 31st 2012 using volumetric method (Hirst, 1952) and a Burkard 7-day trap located on the roof of an office building in the northern part of the city at a height of 3 meters above ground level. To collect pollen grains, Melinex tape coated with petroleum wax was fixed on the rotating drum of sampler. The drum was changed between 8:00 and 9:00 every day and the exposed tape was cut into segments. The pollen slides were embedded in a mixture of glycerin gelatin and stained with 1% aqueous safranin and/or 0.1% fast-green. The whole area of the prepared slides was scanned under a light microscope (Nikon, Japan) at magnification of ×400. Images were captured by an attached digital camera (Nikon, Japan) and stored in the computer. The pollen grains were identified to the genus level, and in two cases to family level, with the aid of appropriate references (Hyde & Adams, 1958; Moore *et al.*, 1991). The total daily counts were converted into the number of pollen grains per cubic meter of air (pollen/m^3).

To establish the main pollen season (MPS), the method proposed by Andersen (1991) was used. This selects the days that, taken together, represent 95% of the annual total, beginning the day that the accumulated value reaches 2.5% of the annual total and ending on the day that 97.5% of the annual total is reached.

In the study, mean air temperature, mean relative humidity, mean rainfall and maximum wind speed, data supplied by Fars Meteorological Bureau, were considered. The correlation between monthly pollen grains and meteorological parameters was calculated by means of a Spearman test. SPSS 16.0 (2007) software package was used for all statistical analyses.

Results

A total of12270 pollen grains from 11 taxa were trapped and counted during 2012 in the atmosphere of Shiraz. The main and abundant pollens belonged to *Pinus* sp. (25.05%), *Buxus* sp. (22.43%), Cupressaceae (18.48%), *Fraxinus* sp. (15.38%) and Poaceae (10.32%) (Table 2). 82.44% of total pollen grains were of trees or shrubs, while herbaceous plants constituted 7.24% of total reported pollen. 10.32% of the counted pollens belonged to the Poaceae family (grass). Tree or shrub pollen type reached its maximum value in April; herbaceous type in March and grass type in June (Fig. 1).

March (39%) followed by April (33.12%) were the months with highest value of pollen counts. During the two months, 72.12% of total pollens were recorded. The minimum pollen number was recorded during July (1.15%). March, April and May included all of the reported types of pollen while low pollen diversity was related to September, October, November, December and January.

In our study, airborne pollen grains increased from February to March and reached their maximum value in March. This sharprise was due to the beginning of pollination period of *Pinus* sp. and to the increase of *Buxus* sp., Cupressaceae and *Fraxinus* sp. pollen levels. Pollen count increase of *Pinus* sp. caused major rise of pollen count during April. During this period, maximum number of *Humulus* sp. and *Reseda* sp. were also recorded. From April toward the end of the year, pollen count declined gradually due to decreasing and/or termination of pollination period of tree taxa. From June to September, major portion of pollen counts belonged to grasses, although *Centaurea* sp. and *Convolvulus* sp. airborne pollen concentrations also increased. During later months of the year, pollen grains of Cupressaceae increased in number again.

Main pollen season, duration, peak day and concentration in a peak day are given in Table 3. Tree or shrub pollen peak days were higher than herbaceous and grass with 489 pollen/m^3 on April, 6 for *Pinus* sp.; 302 pollen/m^3 for *Buxus* sp. on March, 11; 125 pollen/m^3 for *Fraxinus* sp. on April, 12 and 101 pollen/m^3 for Cupressaceae on March, 8. Other taxa did not exceed 15 pollen/m^3, except for Poaceae with 39 pollen/m^3 on June, 16 and *Centaurea* sp. with 30 pollen/m^3 on September, 8. Therefore, Cupressaceae followed by Poaceae and *Centaurea* sp. showed the longest MPS during experiment.

Spearman test was performed to determine the relationship between pollen count and meteorological parameters (Table 4). Pollen grain concentrations of 9 taxa depend on weather conditions in Shiraz. The correlation between pollen count and mean temperature was positive except for Cupressaceae. While wind speed was positively correlated with *Buxus* sp., *Fraxinus* sp., *Humulus* sp., *Pinus* sp. and *Reseda* sp., it was negatively correlated with *Centaurea* sp. While mean relative humidity and rainfall were positively correlated with Cupressaceae pollen count, they were negatively correlated with *Centaurea* sp. and Poaceae. Fig. 2 shows that during February and April, the number of pollen grains in the atmosphere increases. At the same time, mean temperature and wind speed increase while relative humidity and rainfall decrease, compared with previous months.

Discussion

Tree or shrub pollens were dominant in the atmosphere of Shiraz during 2012. Trees have been reported as the main pollen producers, due to their large pollen production per anther and inflorescence (Tormo Molina *et al*., 1996). These types of pollen were also dominant in other areas of the world such as Beirut, Lebanon (Rahal *et al*., 2007), Allahabad, India (Sahney & Chaurasia, 2008), Beijing, China (Xu *et al*., 2012), Sivrihisar, Turkey (Potoglu Erkara, 2008), Istanbul, Turkey (Celenk *et al*., 2010), Salamanca, Spain (Rodríguez-de la Cruz *et al*., 2010) and Philadelphia and Cherry Hill, U.S.A. (Dvorin *et al*., 2001).

March and April had the greatest pollen counts in Shiraz. March in Allahabad, India (Sahney & Chaurasia, 2008) and Lebanon (Rahal *et al*., 2007), and April in Gemlik (Bursa), Turkey (Saatçioğlu *et al*., 2011) were also recorded as the periods with highest pollen grains.

Vegetation type, agricultural and climatic conditions, and therefore the atmospheric pollens and their distribution, vary from one area to another (D'Amato & Spieksma, 1990; Tormo Molina *et al*., 1996). In Shiraz, one peak of airborne pollen (March-April) was recorded during 2012. One pollen season in Lebanon (Rahal *et al*., 2007), Sivrihisar, Turkey (Potoglu Erkara, 2008) and Allahabad, India (Sahney & Chaurasia, 2008) and two peaks in Khairpur, Pakistan (Perveen *et al*., 2014) and Beijing, China (Xu *et al*., 2012) were reported previously.

During 2012, tree and shrub pollen grains reached their maximum levels in April, herbaceous pollens in March and grass pollens in June, whereas for a previous calendar year in Shiraz, Amin & Bokhari (1977) recorded tree and grass pollen peaks during April and May. Tree pollen from February to mid-October and grass pollen from May to mid-November were recorded in the atmosphere of Tehran by Shafiee (1976).

Long periods of Poaceae pollen in the atmosphere of other areas have also been reported (Potoglu Erkara, 2008; Perveen *et al*., 2014). Because of variation in the species number and different phenological periods, pollen grains of this family can be seen in the atmosphere in the whole year (Bicakci *et al*., 2009). Biphasic of Poaceae in mid-May and September was also reported in Philadelphia and Cherry Hill (Dvorin *et al*., 2001). Cupressaceae pollens were also present in the air throughout the year in Shiraz, as reported from other areas (Díaz de la Guardia *et al*., 2006; Celenk *et al*., 2010).

Table 1. Air temperature, RH, rainfall and wind speed in Shiraz during experiment.

Month	Mean temperature (°C)	Mean RH (%)	Mean rainfall (mm)	Maximum wind speed (ms^{-1})
January	7.3	57	70.8	12
February	6.7	55	112.9	9
March	9.2	41	32.8	15
April	15.5	44	11.2	11
May	22.1	34	2.2	11
June	27.4	25	0	10
July	29.3	25	4	10
August	29.5	23	0	8
September	25.9	27	0	7
October	21.1	37	10.2	8
November	14.2	52	98.5	9
December	7.5	68	82.2	8

Table 2. Monthly pollen grain counts in Shiraz during 2012.

Taxa	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total	%
Buxus sp.	0	276	2372	82	14	8	0	0	0	0	0	0	2752	22.43
Centaurea sp.	4	0	5	20	40	68	57	68	130	102	31	21	546	4.45
Convolvulus sp.	0	1	2	4	6	3	12	7	0	0	0	0	35	0.28
Fraxinus sp.	0	88	935	762	77	25	0	0	0	0	0	0	1887	15.38
Humulus sp.	0	0	30	91	50	0	0	0	0	0	0	0	171	1.4
Cupressaceae	212	373	1008	187	19	10	5	68	33	74	142	136	2267	18.48
Morus sp.	0	10	30	46	48	0	0	0	0	0	0	0	134	1.1
Odontites sp.	0	22	79	12	2	0	0	0	0	0	0	0	115	0.93
Pinus sp.	0	0	275	2706	93	0	0	0	0	0	0	0	3074	25.05
Poaceae	3	0	30	142	267	276	68	165	188	76	34	18	1267	10.32
Reseda sp.	0	0	8	12	2	0	0	0	0	0	0	0	22	0.18
Total	219	770	4774	4064	618	390	142	308	351	252	207	175	12270	-
%	1.78	6.27	39	33.12	5.03	3.17	1.15	2.51	2.86	2.05	1.68	1.42	-	100.00

Table 3. Main pollen season, duration, peak day and concentration in a peak day of 11 taxa in Shiraz during 2012.

Taxa	Main pollen season (MPS)	Duration of pollen season (Days)	Date of peak day and value (pollen/m^3)
Buxus sp.	19 Feb. 29 Mar.	39	11 Mar. (302)
Centaurea sp.	21 Apr. 29 Nov.	223	8 Sep. (30)
Convolvulus sp.	28 Feb. 20 Aug.	175	27 May (4)
*Fraxinus*sp.	22 Feb. 13 May	82	12 Apr. (125)
*Humulus*sp.	5 Apr. 5 May	31	25 Apr. (15)
Cupressaceae	10 Jan. 12 Dec.	338	8 Mar. (101)
*Morus*sp.	25 Feb. 18 May	84	16 May (9)
*Odontites*sp.	8 Mar. 17 Apr.	41	19 Mar. (15)
*Pinus*sp.	26 Mar. 30 Apr.	36	6 Apr. (489)
Poaceae	6 Apr. 18 Nov	227	16 Jun. (39)
Reseda sp.	23 Mar. 3 Apr.	12	23 Mar. (5)

Table 4. Coefficients of correlation between four meteorological parameters and 10 plant taxa, in Shiraz during 2012 by using Spearman test (*95%, **99% of signification).

Meteorological factor	*Buxus* sp.	*Centaurea* sp.	*Convolvulus* sp.	*Fraxinus* sp.	*Humulus* sp.	Cupressaceae	*Morus* sp.	*Odontites* sp.	*Pinus* sp.	Poaceae	*Reseda* sp.
Temperature	-0.312	0.802**	0.602*	-0.273	-0.064	-0.839**	-0.254	-0.420	-0.101	0.818**	-0.101
Relative humidity	0.109	-0.742**	-0.646*	0.094	0.037	0.732**	0.142	0.233	0.055	-0.778**	0.055
Rainfall	0.181	-0.797**	-0.467	0.141	-0.037	0.754**	0.147	0.323	0.000	-0.887**	0.000
Wind speed	0.584*	-0.612*	0.323	0.616*	0.618*	0.326	0.571	0.545	0.641*	-0.152	0.641*

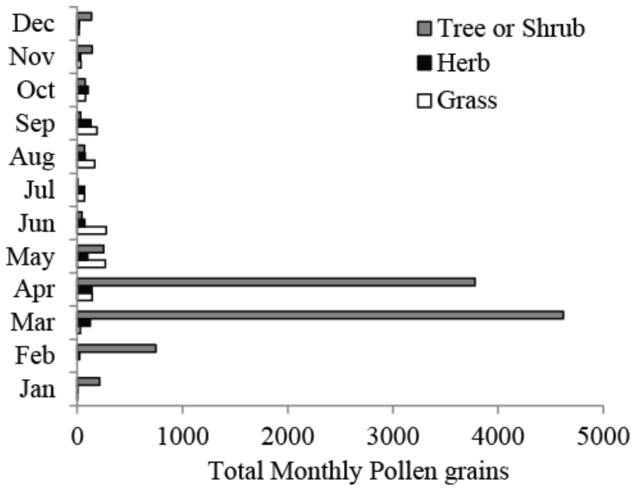

Fig. 1. Monthly variation in tree or shrub, herb and grass pollens in the atmosphere of Shiraz, Iran during 2012.

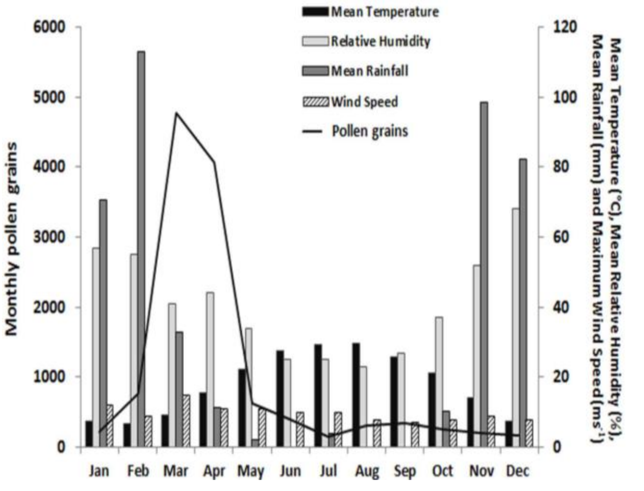

Fig. 2. Meteorological parameters in relation to monthly pollen grains in the atmosphere of Shiraz, Iran during 2012.

The major pollen grains in this study were *Pinus* sp., *Buxus* sp., Cupressaceae, *Fraxinus* sp. and Poaceae. Cupressaceae family and *Pinus* were also recorded among the important trees in Tehran by Shafiee (1976). Some of the pollen types found in high concentration in Shiraz were also found as predominant in other regions: *Cupressus*, *Pinus*, *Fraxinus* and *Buxus* in Lebanon (Rahal *et al*., 2007), *Pinus* spp., Cupressaceae/Taxaceae, *Fraxinus* spp. and Poaceae in Sivrihisar, Turkey (Potoglu Erkara, 2008), *Pinus*, Cupressaceae/Taxaceae, Poaceae in Philadelphia and Cherry Hill (Dvorin *et al*., 2001), *Pinus* spp., Poaceae, Cupressaceae/Taxaceae and *Fraxinus* spp. in Gemlik, Turkey (Saatcioglu *et al*., 2011), Poaceae, Cupressaceae, *Pinus* in Salamanca, Spain (Rodríguez-de la Cruz *et al*., 2010).

In the city of Shiraz, the allergy risk for pollen-sensitive individuals begins in January and February with the rise in the pollen count of Cupressaceae, a known allergenic tree. This sensitivity reaches maximum levels during March and April, with high concentration of pollen from Cupressaceae, *Pinus* sp., *Fraxinus* sp., *Morus* sp. and *Humulus* sp., and then continues during May and June, August and September due to high concentrations of grass (Poaceae) pollens.

Allergenic significance of the pollen from the above-cited trees has already been documented from different regions of Iran: *Juniperus* and *Pinus* in Tehran (Kimiayi, 1970; Shafiee, 1976), *Fraxinus*, *Pinus* and grass pollens in Shiraz (Kashef *et al*., 2003) and Mashhad (Fereidouni *et al*., 2009), *Fraxinus*, *Juniperus* and grass in Karaj (Farhoudi *et al*., 2005) and *Fraxinus americana* and grass in Ahvaz (Assarehzadegan *et al*., 2013).Allergenic importance of Cupressaceae or *Taxus/ Juniperus* (Diaz de la Guardia *et al*., 2006; Liu *et al*., 2010), *Pinus* (Marcos *et al*., 2001, Liu *et al*., 2010), Moraceae (Liu *et al*., 2010), Poaceae (D'Amato & Spieksma, 1990), Asteraceae (Lewis & Vinay, 1979), *Fraxinus* (Hemmer *et al*., 2000; Niederberger *et al*., 2002), *Humulus* (Hong & Park, 1988; Liu *et al*., 2010) were also reported from diverse regions in the world.

We analyzed the correlation between monthly mean temperature, mean relative humidity, mean rainfall and maximum wind speed and the monthly pollen count of each taxon. Majority of the taxa revealed positive correlation with wind speed. Effect of wind speed on pollen distribution has been postulated in several works (Emberlin *et al*., 2000; Kasprzyk & Walanus, 2010). Relative humidity and rainfall showed positive correlation with one taxon (Cupressaceae) and negative correlation with two taxa (*Centaurea* sp. and Poaceae). As noted by Celenk *et al.* (2008) high relative humidity causes hydration of pollens, because of hygrophilous nature of pollen grains, thus they depose to the ground by gravity and the amounts of atmospheric pollens minimize. Although correlation between Cupressaceae and these atmospheric factors was positive in our study, correlation between the pollen concentration and relative humidity and rainfall is usually reported as negative (Celenk *et al*., 2008; Potoglu Erkara, 2008). Temperature is the most considerable climate factor that correlates positively with pollen concentration (McDonald & O'Driscoll, 1980; Minero *et al*., 1999; Potoglu Erkara, 2008). Temperature was positively correlated with three taxa (*Centaurea* sp., *Convolvulus* sp. and Poaceae) and negatively with one taxon (Cupressaceae) in Shiraz. Positive correlation of Poaceae pollen with temperature has also been discussed by Dvorin *et al.* (2001) and Davies & Smith (1974).

Meteorological parameters are the most important environmental variables affecting the pollen grain count. The higher pollen count during March and April can be attributed to low rainfall and relative humidity, higher wind speed and temperature in Shiraz, compared with previous months (Fig. 2).

Recorded plant taxa during this sampling are not close to the survey during 1977 by Amin & Bokhari (1977). It is important to notice that the atmospheric concentration of pollen grains is closely related to the plant phenological data, meteorological and topographical factors, pollen production, long distance transport of pollen, the location and height of the sampler, anthesis, and dispersion (Potoglu Erkara, 2008). Therefore, comparative analysis of data from several successive years and pollen calendars of Shiraz are proposed for future research.

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