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Original article

Allergenic pollen records (15 years) and sensitization in patients with respiratory allergy in Thessaloniki, Greece

Background: Very limited allergenic pollen records exist in Greece so far; moreover, there is a lack of investigation on patient sensitization. The above data are necessary for respiratory allergy diagnosis and treatment worldwide.
Methodology: Daily records and identification of 16 airborne pollen species were made using a Burkard trap (1987–2001). Skin sensitivity to 13 most common pollen extracts was investigated, in a sample of 1311 asthmatics with atopy, admitted to the Out-Patient Clinic for Asthma (1990–2001). Skin sensitivity to 55 allergens, including 13 pollen extracts, was detected by skin prick test.
Results: The following pollen concentrations were recorded: cypress (24.9% of the total), oak (20.8%), wall pellitory (13.6%), olive (9.1%), pine (8.9%), grasses (6.3%), plane (5.4%), hazel (3%), goosefoot (2.5%) and poplar (1.4%). The respective percentages of birch, ragweed, mugwort, willow, alder and elm were lower than 1%. The highest counts of airborne pollen grains were detected from March to June. Regarding patient sensitization, sensitivity was detected to: grasses in 530 patients (40.4%), olive 417 (31.8%), goosefoot 240 (18.3%), wall pellitory 201 (15.3%), mugwort 198 (15.1%), plantain 194 (14.6%), cypress 166 (12.7%), hazel 126 (9.6%), pine 122 (9.3%), poplar 111 (8.4%), plane 107 (8,2%), oak 99 (7.6%) and to birch 89 patients (6.8%). The sensitivity to pollen grains displays preponderance (57.9%) to males.
Conclusions: For the first time in Thessaloniki, Greece, 15-year allergenic pollen records were conducted. Clinical observations confirm that the pollen mainly implicated in respiratory allergy symptoms are grasses, olive and wall pellitory.

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Epidemiologic surveys support that asthma affects 5–30% of children and 2–30% of adults (1, 2). This wide range of intersurvey fluctuation is mainly the result of different geographic distribution and is due to the use of different criteria among studies. Nevertheless, the prevalence of asthma in children, even in the absence of smoking as risk factor, is higher compared with adults. Rhinitis affects 40% of the population; 30% of it concerns seasonal and 10% perennial rhinitis (3). Many studies refer to the interrelationship between asthma and rhinitis; in one report asthmatic patients were asked to fill in questionnaires about rhinitis and the results revealed that asthma occasionally coexisted with rhinitis up to 98.9%. The authors characterize it as 'a chronic allergic disease of airways' (4).

Pollen allergy (hay fever, pollinosis) is a common disease caused by hypersensitivity reaction of the respiratory tract and eye conjunctivae to pollen grains. It concerns seasonal allergic manifestations affecting patients during plant pollination season and includes allergic rhinitis, allergic conjunctivitis, allergic bronchial asthma and less frequently urticaria. The characteristic of seasonal allergy is the recurrent occurrence of symptoms.

The term respiratory allergy refers to clinical manifestations of both upper and lower respiratory tract due to allergy. Patients experience symptoms only during the circulation season of aeroallergens to which they are sensitive.

It is well established that inhalation of pollen grains induces respiratory allergy symptoms in sensitized individuals. These are clinically manifested as rhinitis, rhinoconjunctivitis and bronchial asthma. Dr Sir Charles Blackley, in the nineteenth century for the first time, laid the foundations of the diagnosis and appropriate treatment of seasonal allergic diseases (5); a lot of his observations are still being used by a lot of researchers to date (6).

Many different species of pollen grains disperse in the atmosphere and they are correlated with the flora of each region. Pollen grains are highly specialized microspores of the male structure of the plant flower, necessary for the reproduction of plants (7, 8). Their atmospheric presence is strongly influenced by meteorologic conditions in each area (9). The recording and forecasting of pollen dispersion in the atmosphere attract the majority of scientists and specialists interest for several reasons.

In medicine the main aim of scientific research is the creation of pollen calendars, used for the estimation of the flowering and pollen circulation season during which clinical symptoms occur and, moreover, the forecasting of different allergenic pollen species in various regions.

Aim of the study

The aim of the study was the creation of a database including long-term records made on a daily basis and the identification of pollen with allergenic interest in the area of Thessaloniki, Greece (creation of pollen calendar). It was considered necessary to detect the skin sensitivity of asthmatic patients to pollen, which are the most frequently implicated to respiratory allergy symptoms (10).

Study area

Thessaloniki is an old city that celebrated its 2300-year anniversary of foundation in 1984. The city is built in the heart of Thermaikos Gulf in the Aegean Sea and its geographic location is 40°37′N and 22°57′E. Nowadays, Thessaloniki is an industrialized modern city of more than one million inhabitants, the second biggest city in Greece, the cultural and economic center of Macedonia and northern Greece and an important seaport.

In the north-east of Thessaloniki there is a large forest of pines, cypresses, cedars and oaks, called 'Kedrinos Lofos'. In the western side, where the industrial zone is well developed, the city is in contact with extensive fields of cultivated cereals. The east part of the city is close to grass areas and olive trees, neighboring on the peninsula of Chalkidiki. In the south the city borders on the Mediterranean Sea.

Material and methods

The study design included:

1. Daily records and identification of more than 40 pollen grain species belonging to different plant taxa. Selection of the 16 most significant for presentation, as far as their allergenicity is concerned.
2. Creation and presentation of pollen calendar for the most allergenic pollen.
3. Detection of skin sensitivity to allergenic pollen in asthmatics.
4. Detection and presentation of start, peak and end dates of pollen circulation season.

Records, identification and presentation of pollen in the atmosphere of Thessaloniki

This study began in September 1986, when the Burkard volumetric spore trap was installed in the center of Thessaloniki. Daily sampling of airborne pollen started on February 1, 1987 and continues until today. In this study, 15-year records are being presented, a period long enough for the creation of pollen calendars in an area (11).

The records of pollen grains were made using a Burkard 7-day recording volumetric trap, equipment standard for aerobiologic sampling worldwide (7, 8, 12, 13). The trap was placed on the roof of a six-floor building in the center of Thessaloniki and at a height of 25 m above the ground, collecting pollen grains in the ambient air throughout the study (7). The Burkard trap is a compact unit with built-in vacuum pump, designed to sample airborne particles, such as pollen grains, continuously for periods of up to 7 days without attention. Particles are impacted on adhesive-coated transparent plastic tape supported on a clock-work-driven drum. The drum moves 2 mm/h and thus the concentration of airborne particles can be calculated hourly. The vacuum pump draws about 10 l of air/min through a thin orifice, a function that is not influenced by weather conditions. The tape is coated with a special type of silicone ('Gelvatol' silicone grease, Burkard Manufacturing Company Ltd, UK). The drum makes a complete revolution after a week; then, the tape is taken, it is cut into seven pieces – each piece representing a single day of sampling, that is 48 mm of tape and these are mounted on slides with glycerin and saffranine under cover slips. Recognition and counting of pollen grains is performed under a light microscope (40×). Pollen grain counts are expressed as pollen grains per cubic meter of air (7, 10, 12).

Data are presented as average values per 10 days in accordance with the International Association for Aerobiology (11). Sometimes these values are expressed as moving average values per 10 days (running means).

Running means or moving average values for a specific period of time is a statistic technique used for presentation of values with great variation, in order that their variance is smoothed. In this way, we are able to more easily observe the general trend, which is more valuable than the daily variation of values. In the occasion of airborne pollen, decrease of intervariations in recorded values allow us to predict the general trend of aeroallergen concentrations, a measure much more significant than the mere daily fluctuation.

Creation and presentation of pollen calendar

Data of pollen grain records were inserted in an automated computer worksheet and processed with Microsoft Excel for Windows. The pollen calendar was created according to the methodology referred to 'Allergenic pollen and pollinosis in Europe' (11). Pollen grains were expressed in average daily values and then, in our occasion, as average daily values per 10 days, for the 15-year period (1987–2001). They were presented on a specific scale, each level corresponding to a particular amount of pollen grains. These levels were: first: total sum of one to two pollen grains per 10 days, second: three to five pollen grains, third: six to 11 pollen grains, fourth: 12–24 pollen grains, fifth: 25–49 pollen grains, sixth: 50–99 pollen grains, seventh: 100–199 pollen grains, eighth: 200–399 pollen grains, ninth: 400–799 pollen grains, 10th: 800–1599 pollen grains and 11th: a sum of more than 1600 pollen grains per 10 days. In this way, all interactions between external factors and pollen concentrations were significantly decreased, enabling us to compare different pollen species concentrations throughout the year. The daily pollen grains average values per 10 days were presented for the 15-year period (1987–2001); they concerned only the main pollen season, that is, from February 1 to September 30.

Detection of skin allergic sensitization to pollen extracts in asthmatic patients

The study refers to 1744 patients admitted to the Out-Patient Clinic for Asthma of the Pulmonary Department of Aristotle University of Thessaloniki in the General Hospital 'G. Papanikolaou' from January 1, 1990 until the end of 2001. The patients included in the study were necessary to have presented annual periodicity, seasonal occurrence of symptoms and/or worsening of respiratory allergy symptoms. The examination of patients included:

1. Filling in a questionnaire of 200 questions specific for asthma. This can be electronically processed, thus enabling us to examine the relation between skin allergic sensitization (skin prick tests, SPT) and the onset of clinical symptoms.
2. Clinical examination.
3. Spirometry and, in some cases, bronchial challenge test with metacholine or histamine.
4. Chest X-ray film.
5. Specific IgE (detected only in some cases).
6. Skin tests.

Skin tests were performed by a modified skin prick technique. The most common inhalant and food allergens were used, a total of 55 extracts, including 13 pollen extracts. The selection of pollen species was made according to the local vegetation and to expected sensitization, as documented by past studies made in our country, Europe and the USA (10, 14–26). The allergens were either isolated or in groups. All the allergens were produced by Allergopharma J. Ganzer KG (Reinbek, Germany). The pollen extracts used were: grasses family – two mixes (f. Poaceae), olive family (c. olive, ash, f. Oleaceae), nettle family (c. wall pellitory, f. Urticaceae), cypress family (c. cypress, juniper, cedars, f. Cupressaceae), composites family (c. ragweed, mugwort, f. Asteraceae/Compositae-Tubuliflorae), plane family (c. plane, f. Platanaceae), goosefoot family (c. goosefoot, f. Chenopodiaceae), hazel (*Corylus* spp., f. Corylaceae), plantain (f. Plantaginaceae), pine (f. Pinaceae), poplar (*Populus* spp., f. Salicaceae), oak (*Quercus* spp., f. Fagaceae) and birch (*Betula* spp., f. Betulaceae). Skin positivity was recorded 15 min after the test and the wheal and flare reactions were impressed on transparent cellophane. Positivity was expressed in wheal diameter > 3 mm and flare diameter > 10 mm compared with negative and positive controls (6, 10, 27, 28).

Presentation of start, peak and end of pollen circulation season

As the start of pollen circulation season, we regard the time when the amount of pollen grains count up to 5% of total average amount of pollen grains recorded during the previous years, that is, the 15-year period (1987–2001). The peak is considered to be the specific day on which the greatest number of pollen grains was recorded – always compared with the 15-year period of sampling. Likewise, we consider the 95% to be the end of pollen circulation season, also compared with the average values of pollen grains records of the previous years (29, 30).

This 'prediction system', called 5–95%, actually takes into consideration not only the time when pollen begin to disperse in the atmosphere, but also the time when the first clinical symptoms – because of them – occur. Therefore, this appears to be the clinical onset and end of the pollen circulation season, which appeals to the beginning and end of the clinical symptoms of allergic patients with moderate sensitivity to pollen allergens.

Results

Aerobiologic records of pollen

More than 40 pollen species were recorded and identified during the 15-year period of sampling. However, only 16 of them, the most common implicated in respiratory allergy symptoms worldwide, are being presented in this study. The airborne pollen records in the area of Thessaloniki during the 15-year period (1987–2001) are presented in Table 1. Significant variations are observed among different species each year. The annual average pollen total concentration is displayed in Fig. 1, in moving average values per 10 days (running means) for the 15-year period of

Table 1. Total annual concentrations of each pollen species, annual sum of all species concentrations and their percentages (%) for each one of the 16 pollen species recorded in the area of Thessaloniki during 1987–2001

Pollen species	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Total	Average	%
Cypress (Cupressaceae)	6432	658	901	619	1216	3044	1634	1850	1772	1153	3660	2621	7651	1865	4069	39 145	2610	24.9
Oaks (*Quercus* spp.)	1532	2544	1593	1958	1575	1465	579	1078	1568	1543	3693	1091	3105	7422	1911	32 657	2177	20.8
Wall pellitory (Urticaceae)	217	270	1714	229	1513	302	1342	614	379	2001	2925	2318	3332	2517	1759	21 432	1429	13.6
Olive, Ash (Oleaceae)	155	409	236	407	1201	1398	1226	413	389	1636	1339	659	2399	1490	1022	14 379	959	9.1
Pine (Pinaceae)	403	604	805	587	659	932	1111	405	661	1105	1145	696	1482	2672	779	14 046	936	8.9
Grasses (Poaceae)	365	430	398	439	603	241	346	303	267	877	1267	784	1956	979	674	9929	662	6.3
Plane (Platanaceae)	44	328	321	287	265	318	286	164	50	1117	341	433	1819	1528	1210	8511	567	5.4
Hazel (*Corylus* spp.)	100	363	301	287	247	136	190	150	80	379	734	350	430	253	656	4656	310	3.0
Goosefoot (Chenopodiaceae)	77	154	150	256	333	156	188	125	134	453	501	386	378	376	281	3948	263	2.5
Ragweed, Mugwort (Compositae)			118	133	283	176	179	164	121	169	162	93	209	297	138	2242	172	1.4
Poplar (*Populus* spp.)	229	209	178	186	126	84	122	109	107	13	219	242	216	65	104	2209	147	1.4
Plantain (Plantaginaceae)	16	18	37	10	10	33	56	83	57	52	127	107	296	198	129	1229	82	0.8
Willow (*Salix* spp.)	19	86	31	21	75	46	66	29	34	137	73	127	73	61	65	943	63	0.6
Alder (*Alnus* spp.)	53	14	8	10	85	25	58	84	114	0	107	107	67	66	97	895	60	0.6
Elms (Ulmaceae)	25	16	32	10	42	40	37	29	21	0	94	79	86	43	56	610	41	0.4
Birch (*Betula* spp.)	17	7	14	7	31	38	54	24	35	65	87	51	29	34	1	494	33	0.3
Total	9684	6110	6837	5446	8264	8434	7474	5624	5789	10 700	16 474	10 144	23 528	19 866	12 951	157 325	9625	

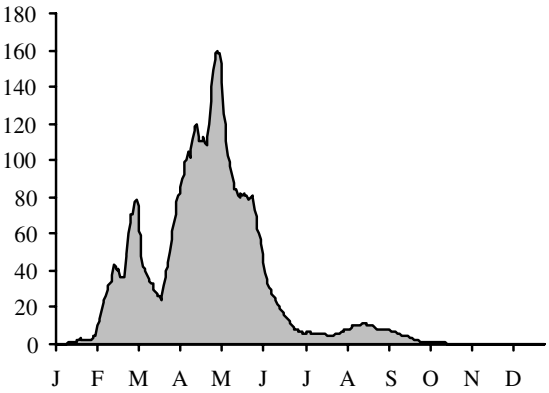

Figure 1. Ten-day moving average values of the total amount of pollen grains for the 15-year period of records in the area of Thessaloniki.

records. The concentrations of each pollen species (moving average values per 10 days) are presented in Figs 2 and 3. In Fig. 4, the pollen calendar including all recorded aeroallergens is displayed.

Detection of skin allergic sensitization to pollen

From a sample of 1744 patients examined for allergic sensitization to pollen, 1569 (90%) were born and lived in the area of Thessaloniki. The other 175 (10%) have lived in the study area for the last 10 years. Their average age was about 35 years old (6–68 years old) and average duration of asthma was 23 months (3 months to 10 years). Skin positivity to one or more allergen extracts of the 55 tested occurred in 1311 (75.2%) patients, while 433 patients (24.8%) had a negative reaction. About 552 of the 1311 patients reacting positively to skin prick tests were women (42.1%), whereas 759 (57%) were men. On the contrary, concerning the 433 patients having presented negativity to skin prick tests, 260 were women (60%) and 173 patients (40%) were men. The majority of patients with a positive reaction to pollen simultaneously presented a positive medical history and clinical symptoms, occurring mostly during March–May and, partially, July–August (Table 2).

A total of 530 patients (40.4%) presented positive skin allergic reaction to grasses (Poaceae), 417 allergic patients (31.8%) to olive (*Olea europaea*), 240 patients (18.3%) to goosefoot (Chenopodiaceae), 201 (15.3%) to wall pellitory (*Parietaria* spp.), 198 (15.1%) to ragweed and mugwort (Compositae), 194 (14.8%) to plantain (Plantaginaceae) and 166 patients (12.7%) to cypress (Cupressaceae). Moreover, 126 allergic patients (9.6%) presented skin sensitivity to hazel pollen, 122 (9.3%) to pine (Pinaceae), 111 (8.4%) to poplar (*Populus* spp.), 107 (8.2%) to plane (Platanaceae), 99 (7.6%) to oak (*Quercus* spp.) and 89 allergic patients (6.8%) displayed skin sensitivity to birch (*Betula* spp.).

Start, peak and end date of pollen circulation season in the area of Thessaloniki

According to the 'prediction system 5–95%' (Table 3), seven pollen species begin their circulation season in February, one pollen species in March, six in April, one in May (Chenopodiaceae) and one pollen species in July (Compositae). The respective end of pollen circulation season was observed for one species in March (*Alnus*), for one species in April (Ulmaceae), for six in May, for four in June and for four pollen species in September. The highest levels of pollen grains in the atmosphere of Thessaloniki occurred for 13 species from February to May, whereas for the rest three species between June and August. May is the month with the highest concentrations of airborne pollen (five species) (Table 3).

Discussion

All components of atmosphere do not present the same allergenic significance for human. Pollen grains have been studied as aeroallergens. Pollen allergy is involved with local vegetation and depends on the way and duration of exposure to aeroallergens, provided of course that there is a genetic predisposition to respiratory allergy (23, 31, 32). Many researchers relate the occurrence of respiratory allergy symptoms with the presence of pollen grains in ambient air; besides, it is well documented that inhalation of specific species of pollen grains causes clinical symptoms of respiratory allergy (5, 6).

Concentrations of airborne pollen in the atmosphere of Thessaloniki vary both for the annual total amount of pollen and for the annual values of different species for the 15-year period of records. This is not a rare incidence in the plant world; on the contrary, it happens every year and is due to several reasons. Therefore, it is necessary to obtain long-term records, so as to ensure the stability of predicted pollen grain concentrations in the atmosphere (11). Recorded pollen counts and their annual variability from 1987 to 2001 are presented in Table 1. Allergenic airborne species appear in the area of Thessaloniki only from the end of January to the end of September (Fig. 1). The highest concentrations of pollen were observed from the beginning of March until the start of June (Fig. 2); during that period, it is estimated that 81% of the total annual amount of pollen grains circulates in the air of the city.

A wide range of factors affects the production, dispersion and transportation of airborne pollen. It is widely documented that a favorable combination of air temperature, relative humidity and sunshine ('growth degree days' or 'day degree units') is needed by each plant to shed its leaves, flowers and fruits every year. As long as each plant is under these 'excellent' conditions for a minimum period of time, it is capable of reproduction (33). The exact number of pollen grains

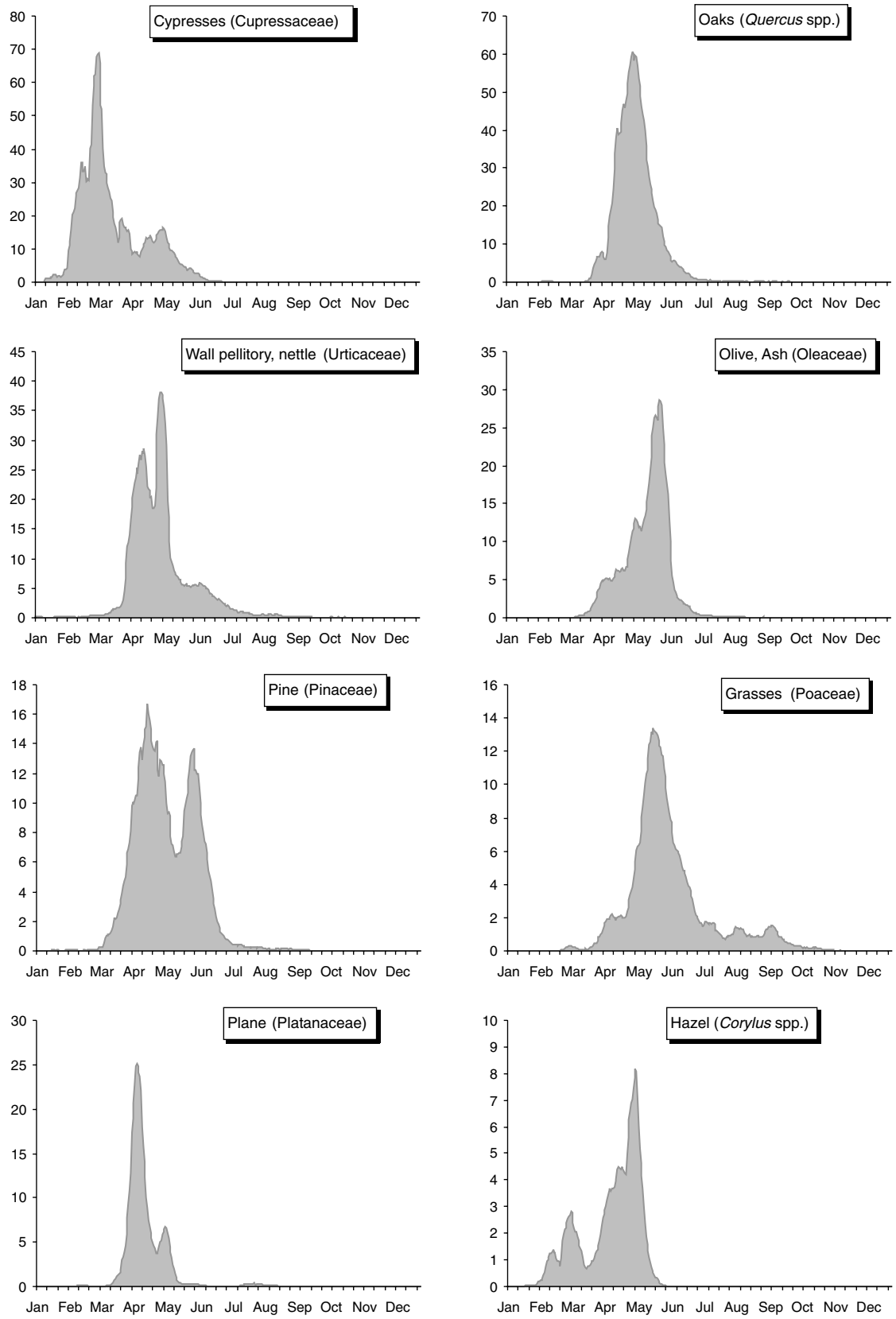

Figure 2. Group of graphs I: Ten-day moving average values of eight pollen species for the 15-year period of records in the area of Thessaloniki.

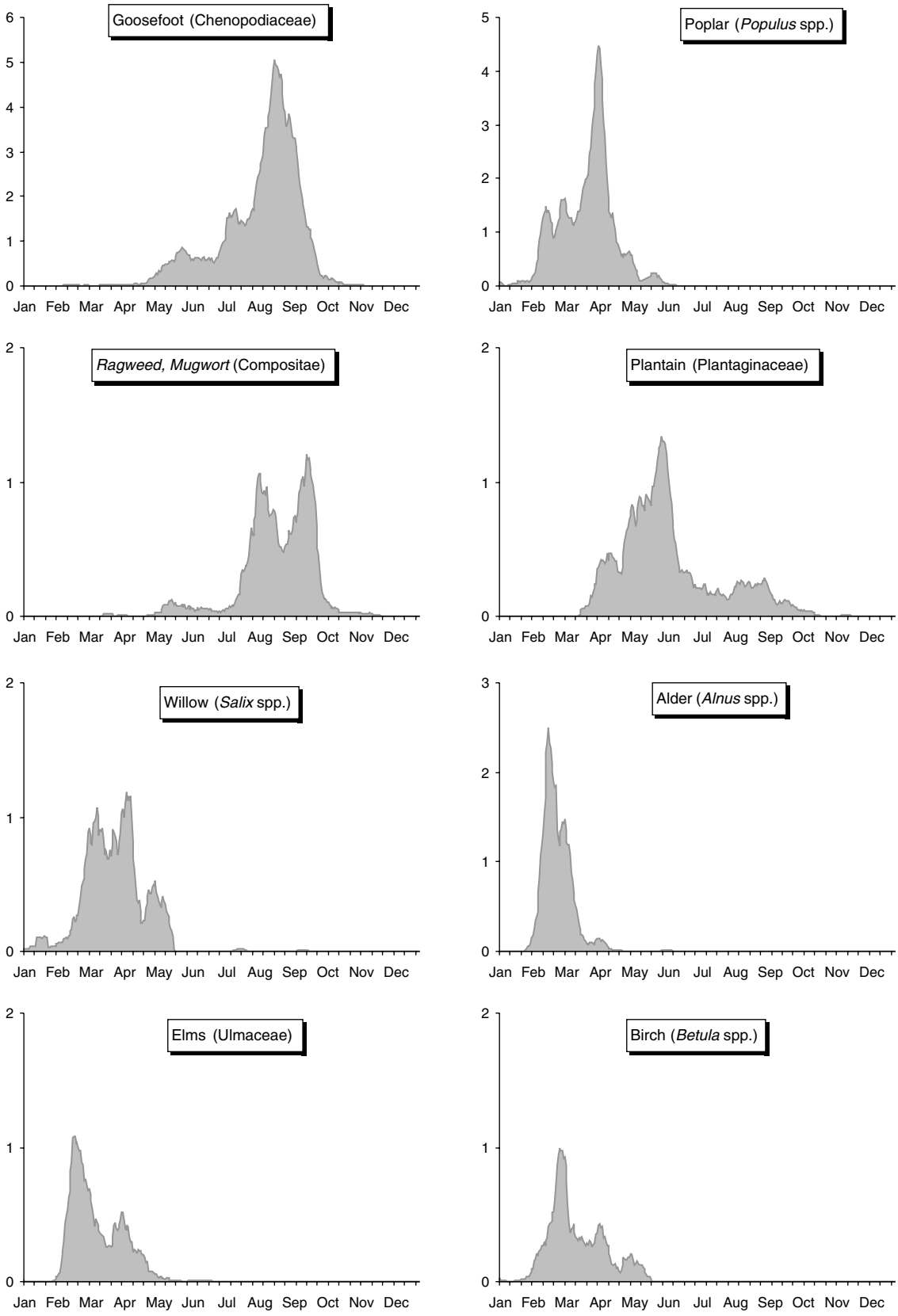

Figure 3. Group of graphs II: Ten-day moving average values of eight pollen species daily for the 15-year period of records in the area of Thessaloniki.

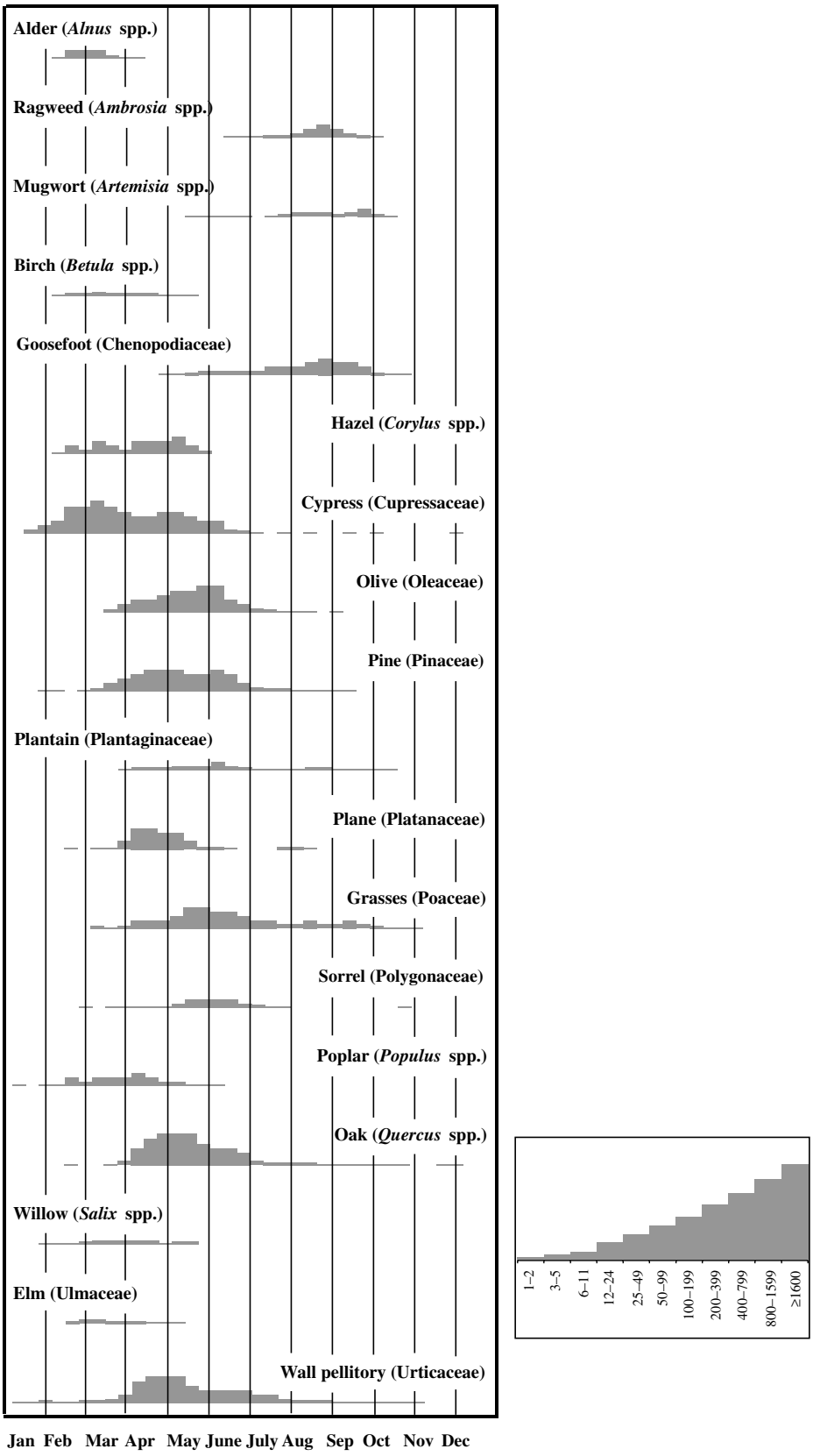

Figure 4. Pollen calendar of 18 pollen species in summed 10-day average values for the 15-year period of records in the area of Thessaloniki. It is also presented the scale with the specific levels of pollen concentrations.

Table 2. Patient sensitization to 13 pollen, presented as percentages of the total 1311 patients with respiratory allergy examined. Distribution of sensitization to two sexes

Pollen species	Sensitization, *n* (%)	Sex distribution	
		Men (%)	Women (%)
Grasses (Poaceae)	530 (40.4)	285 (53.8)	245 (46.2)
Olive, Ash (Oleaceae)	417 (31.8)	225 (54.0)	192 (46.0)
Goosefoot (Chenopodiaceae)	240 (18.3)	135 (56.3)	105 (43.7)
Wall pellitory (Urticaceae)	201 (15.3)	108 (53.7)	93 (46.3)
Ragweed, Mugwort (Compositae)	198 (15.1)	112 (56.6)	86 (43.4)
Plantain (Plantaginaceae)	194 (14.8)	115 (59.3)	79 (40.7)
Cypress (Cupressaceae)	166 (12.7)	91 (54.8)	75 (45.2)
Hazel (*Corylus* spp.)	126 (9.6)	73 (58.0)	53 (42.0)
Pine (Pinaceae)	122 (9.3)	84 (68.9)	38 (31.1)
Poplar (*Populus* spp.)	111 (8.4)	63 (56.7)	48 (43.3)
Plane (Platanaceae)	107 (8.2)	68 (63.6)	39 (36.4)
Oaks (*Quercus* spp.)	99 (7.6)	52 (53.0)	47 (47.0)
Birch (*Betula* spp.)	89 (6.8)	57 (64.0)	32 (36.0)

expected to disperse in the atmosphere and the duration of their circulation season in a specific region depend on wind direction and speed, rainfall height and duration and relative humidity during the flowering season (8). Hence, plant growth conditions may be reproduced in a laboratory; however, the conditions of pollen grain circulation in the atmosphere cannot be easily reproduced and seem to be specific for each different species. Moreover, the presence of pollen in ambient air is significantly influenced by inner functions of the plant's flower that have been referred to as the result of meteorologic parameter interactions (7). Many studies suggest that it is necessary to record and correlate the airborne pollen concentrations with the most important meteorologic parameters values (34). As annual inter-variations can be really high, the average values are preferably used, for a period of sampling as long as possible (11). Thus, we used the average values of pollen concentrations (Table 1, Fig. 1) for the 15-year period of records (1987–2001), in order to ensure the production of safe results. An example of a great annual internalization can be seen between year 1987 (9684 total pollen grains) and year 1994 (5624 total pollen grains), concentrations almost half of those in 1987. Furthermore, in 1999, that is 2 years after a great fire in a large forest in our area, called 'Kedrinos Lofos' the highest values in the whole 15-year period were observed, despite the fact that about 60% of the forest's area had been burnt. Other researchers have also documented similar very significant differences in annual pollen counts (7). It is therefore concluded that nature follows its own rules, which are very hard for us to understand and explain thoroughly. It is strongly believed that more studies on 'middle height' atmospheric phenomena would draw safer conclusions about airborne pollen circulation.

As far as skin prick tests are concerned, they present a high diagnostic value, especially if combined with the patient's medical history. Positivity in skin tests is not usually observed to individuals lacking clinical symptoms (30). The method of modified SPT proves to be a reliable tool for detection of type I sensitivity in humans worldwide (10, 28, 35). In addition, the results can be stored in transparent cellophanes, enabling us to compare the results of the test at a given time with those at different periods or with other patient tests, even from abroad. The positivity of skin prick tests strongly correlates with bronchial hyper-responsiveness and other clinical aspects of bronchial asthma (36). Moreover, it is reported that skin prick tests are more reliable than

Table 3. Dates of start, peak and end of each pollen species circulation season, according to the `prediction system 5–95%

Pollen species	Start (5%)	Peak	End (95%)
Cypress (Cupressaceae)	February 11 (123)	March 5 (151)	May 17 (2346)
Oaks (*Quercus* spp.)	April 14 (109)	May 5 (78)	June 10 (2080)
Wall pellitory (Urticaceae)	April 5 (70)	May 5 (101)	June 29 (1335)
Olive, Ash (Oleaceae)	April 8 (48)	May 28 (39)	June 14 (908)
Pine (Pinaceae)	March 31 (47)	April 25 (27)	June 19 (900)
Grasses (Poaceae)	April 17 (33)	May 26 (17)	September 6 (628)
Plane (Platanaceae)	April 2 (26)	April 10 (48)	May 12 (495)
Hazel (*Corylus* spp.)	February 20 (14)	May 4 (14)	May 15 (271)
Goosefoot (Chenopodiaceae)	May 27 (13)	August 27 (7)	September 24 (249)
Poplar (*Populus* spp.)	February 15 (8)	April 6 (6)	May 5 (143)
Ragweed, Mugwort (Compositae)	July 9 (9)	August 17 (6)	September 27 (166)
Plantain (Plantaginaceae)	April 12 (4)	June 4 (2)	September 11 (75)
Willow (*Salix* spp.)	February 21 (3)	March 15 (2)	May 12 (58)
Alder (*Alnus* spp.)	February 12 (3)	February 22 (6)	March 26 (55)
Elms (Ulmaceae)	February 15 (2)	February 24 (3)	April 25 (38)
Birch (*Betula* spp.)	February 12 (2)	March 4 (2)	May 4 (33)

In brackets, the concentration of each species is presented for the respective date. For 5 and 95%, these concentrations correspond to the sum of pollen grains adding up to the 5 and 95%, respectively, of the total annual amount of pollen, whereas for the peak it represents an actual daily value.

detection of total and special IgE tests (35). In everyday medicine and asthma, the problem of respiratory allergy caused by pollen inhalation is very common. Few references exist in Greek literature about the incidence of pollen allergy and skin sensitivity in Greek citizens. Only very recent studies conducted in Greece refer to this problem (15, 25, 26). Our data concern a significant number of patients suffering from respiratory allergy (1744 patients), who live in the county of Thessaloniki, the area of the 15-year allergenic pollen study. The pollen species selected are regarded as mainly implicated in respiratory allergy symptoms in the most European countries (7, 8, 10, 12, 15, 20–22, 24). SPTs were performed during the period 1990–2001, which coincides with the period of pollen sampling. Among the 1744 asthmatic patients tested, 1311 (75.2%) of them presented skin positivity, whereas only 433 (24.8%) were negative to SPTs (Table 2). Similar results were taken both from Greek (26) and international studies (20, 21). According to every patient's medical history, they displayed increased asthma symptoms during the peak of pollen circulation season, that is between March and May. Furthermore, skin positivity to pollen was more often observed to men (759, 57.9%) than to women (552, 42.1%). This fact has been referred to by other scientists as well (15, 26) and is mainly due to genetic and hormonic factors, probably in addition to the impact of some external factors.

Frequency of SPT sensitization did not necessarily present a positive relationship with pollen grain concentrations in the air of Thessaloniki. Therefore, although many asthmatics presented a high SPT sensitivity (40.4%) to grasses (Table 2), pollen concentrations are only ranked at the sixth position of aeroallergen circulation in the area of Thessaloniki (Table 1). On the contrary, SPT sensitivity to oak was only 7.6% (Table 2), although it is the second most frequently detected aeroallergen in the region (Table 1). All these data are also documented by international references (6–8, 14).

By means of clinical observations – including SPTs – and medical history of patients, it was clearly observed that annual variability of pollen grains in the ambient air coincided with respective increase or decrease of allergic symptoms in sensitized individuals, whenever the latter were highly exposed to aeroallergens, as referred to references worldwide (7, 10, 14).

Forecasting of allergenic pollen season in an area is a crucial pursuit for all developed countries, in order to minimize clinical symptoms of patients suffering from respiratory allergy. This can be achieved through public announcements by the mass media (radio, television, teletext, telephone, Internet, etc.), aiming to protect allergic individuals. Thus, the total cost of disease treatment is finally reduced; in fact, it is assessed that this kind of massive protective treatment can decrease the number and frequency of visits to medical doctors by 50% (37). In this direction, we used the 'prediction system 5–95%' as the start and end, respectively, of the flowering season for each pollen species studied. Therefore, it is possible for every researcher to specify the onset and end of pollination season, during which the first clinical symptoms are expected to occur. Moreover, the particular day of the highest average pollen concentration for each species was detected. These predictions may vary significantly among different regions and for each plant species and they surely depend on previous years records (29, 30). The longest the sampling period, the more reliable and accurate the prediction of the 'clinical' start and end dates will be. Clinical start refers to the onset of symptoms of patients who live inside the city and present a moderate sensitivity. This had been examined with special questionnaires filled in by patients sensitive to allergenic pollen grains (cypress, wall pellitory, olive and grasses) and simultaneous comparison with the amount of airborne pollen in this area for the respective period of time (38). The knowledge of the start, peak and end of pollen circulation season for every allergenic pollen species is undoubtedly essential both for doctors and patients.

Conclusions

Records of 16 allergenic pollen species were conducted in the area of Thessaloniki during the last 15 years (1987–2001) and are presented in a pollen calendar, a fact very important for our city and country both from medical and biologic view. The most frequently recorded pollen grains in the region were of: 1) cypress, 2) oak, 3) wall pellitory and 4) olive.

Skin sensitivity to 13 pollen species was detected in patients with respiratory allergy in the region of Thessaloniki. The main pollen involved in respiratory allergy symptoms were selected. The most frequently implicated pollen in SPT sensitization of patients were: 1) grasses, 2) olive, 3) goosefoot and 4) wall pellitory.

All data are presented in our area for the first time and could comprise the infrastructure of many medical, biologic and other scientific fields' applications.

References

1. Burney PG, Luczynska C, Chinn S, Jarvis D. The European Community Respiratory Health Survey. Eur Respir J 1994;**7**:954–960.
2. The International Study of Asthma and Allergy in Childhood (ISAAC) Steering Committee. World wide variation in prevalence of symptoms of asthma, allergic rhinoconjuctivitis and atopic eczema (ISAAC). Lancet 1998;**351**: 1225–1232.
3. Sibbald B, Strachen D. Epidemiology of rhinitis. In: Busse W, Holgate S, editors. Asthma and rhinitis. Boston: Blackwell Scientific Publications, 1995:32–34.
4. Simons FR. Allergic rhinobrochitis: the asthma–allergic rhinitis link. J Allergy Clin Immunol 1999;**104**:534–540.
5. Blackley C. On hay fever. Experimental researches. Abington: Oxford Historical Books, 1988.
6. Mygind N, Dahl R, Pedersen S, Thestrup-Pedersen K. Essential allergy, 2nd edn. Melburn-Paris-Berlin-Vienna: Blackwell Scientific Publications, 1996:3.
7. Bush R. Aerobiology of pollen and fungal allergens. J Allergy Clin Immunol 1989;**64**:1120–1124.
8. Solomon W. Aerobiology of pollinosis. J Allergy Clin Immunol 1984;**74**:449–461.
9. Mandrioli P, Negrini M. Weather and climate in Europe. In: D'Amato G, Spieksma FT, Bonini S, editors. Allergenic pollen and pollinosis in Europe. Melburn-Paris-Berlin-Vienna: Blackwell Scientific Publications, 1991:3–17.
10. Galant S, Berger W, Gillman S, Goldsobel A, Incaudo G, Kanter L et al. Prevalence of sensitization to allergens in California patients with respiratory allergy. Allergy skin test project team. Ann Allergy Asthma Immunol 1998;**81**:203–210.
11. Spieksma F. Regional European pollen calendars. In: D'Amato G, Spieksma FT, Bonini S, editors. Allergenic pollen and pollinosis in Europe. Melburn-Paris-Berlin-Vienna: Blackwell Scientific Publications, 1991:49–65.
12. Rantio-Lehtimaki Á. Sampling airborne pollen and pollen antigens. In: D'Amato G, Spieksma FT, Bonini S, editors. Allergenic pollen and pollinosis in Europe. Melburn-Paris-Berlin-Vienna: Blackwell Scientific Publications, 1991:18–23.
13. Kersten W, Puls K. Pollen flight forecast – Results by a pilot study 1981–1982, in Nordrhein-Westfalen. Allergologie 1984;**7**:81–114.
14. Gioulekas D, Chatzigeorgiou G, Spieksma F. Allergenic pollen and pollinosis in northern Greece. In: D'Amato G, Spieksma FT, Bonini S, editors. Allergenic pollen and pollinosis in Europe. Melburn-Paris-Berlin-Vienna: Blackwell Scientific publications, 1991:167–171.
15. Grigoreas C, Vourdas D. Sensitization frequency (positive skin-prick tests) in inhaled aeroallergens of pollen to patients with seasonal respiratory allergy (rhinoconjuctivitis, asthma). Hellenic Allergiol Clin Immunol 1996;**2**:100–108.
16. Spieksma F, Charpin H, Nolard N, Stix E. City spore concentration in the European Economic Community. Summer weed pollen (Rumex, Plantago, Chenopodiaceae, Artemisia). Allergy 1980;**35**:593–603.
17. Spieksma F, Van De Assem A, Collette B. Airborne pollen concentration in Leiden, The Netherlands, 1977–1981. Poaceae (grasses), variations and relation to the Hay fever. Grana 1985;**24**: 99–108.
18. Spieksma F, Frenguelli G, Nikkels A, Mincigrugcci G, Smithuis L, Bricci E et al. Comparative study of airborne pollen concentrations in central Italy and The Netherlands (1982–85). Emphasis pollen Alnus, Poaceae, and Artemisia. Grana 1989;**28**:25–36.
19. D'Amato G, Mullin J, Nolard N, Spieksma F, Wachter R. City spore concentration in the European Economic Community. Oleaceae (Fraxinus, Ligustra, Olea). Clin Allergy 1988;**3**:541–547.
20. D'Amato G, Lobefalo G. Allergenic pollens in southern Mediterranean area. J All Clin Immunol 1989;**83**:116–122.
21. D'Amato G, Spieksma FT, Liccardi G, Jager S, Russo M, Kontou-Fili K et al. Pollen related allergy in Europe. Allergy 1998;**6**:567–578.
22. Negrini A. Skin tests. In: Falagiani P, editor. Pollinosis. Boca Raton: CRC Press Inc., 1990:140–150.
23. Horak F, Jaeger S. Basic facts of the allergen avoidance in pollinosis. Different kinds of pollen and flowering times in Europe. Allergologie 1983;**6**:113–118.
24. Giner M, Selles. Allergenic pollen in southeast Spain. Allergy 2002;**57**:59–60.
25. Papageorgiou PS. Particularities of pollen allergies in Greece. Pediatr Pulmonol Suppl 1999;**18**:168–171.
26. Grigoreas Ch, Vourdas D. Frequency of atopy in asthmatics with bronchial asthma. Impact of age. Hellenic Soc Allergol Clin Immunol 2000;**8**: 33–42.
27. Van Metre T, Adkinson N, Kagey-Sobotka A, Marsh D, Norman P, Rosenberg G. How should we use skin testing to quantify IgE sensitivity? J Allergy Clin Immunol 1990;**86**: 583–586.
28. Niemeijer NR, De Monchy JG. Age-dependency of sensitization to aeroallergens in asthmatics. Allergy 1992;**47**:431–435.
29. Driessen M, Van Herpen R, Moelands R, Spieksma F. Prediction of the start of the pollen season for the western part of the Netherlands. Grana 1989;**28**:37–44.
30. Nilsson S, Piersson S. Tree pollen spectra in the Stockholm region (Sweden), 1973–80. Grana 1981;**20**:179–182.
31. Nelson H. The importance of allergens in the development of asthma and the persistence of symptoms. J Allergy Clin Immunol 2000;**105**:628–632.
32. Sears MR, Burrows B, Flannery EM, Herbison GP, Holdaway MD. Atopy in childhood. I. Gender and allergen related risks for development of hay fever and asthma. Clin Exp Allergy 1993;**23**:883–885.
33. Munn R. Biometeorological methods, degree days. Environmental sciences. New York and London: Academic Press, 1970:155–163.
34. Mandrioli P. Aerobiology-pollen sampling, influence of climate, pollen sources and pollen calendar. In: Falagiani P, editor. Pollinosis. USA: CRC Press Inc., 1990:39–53.
35. Tscopp JM, Sistek D, Schindler C, Lauenbberger P, Perruchoud AP, Wuthrich B et al. Current allergic asthma and rhinitis: diagnostic efficiency of three commonly used atopic markers (IgE, skin prick test, and Phadiatop). Results from 8329 randomised adults from the SAPALDIA Study. Swiss study on air pollution and lung disease in adults. Allergy 1998;**53**:608–613.

36. Borrows B, Sears M, Flannery E, Herbison P, Holdaway MD. Relations of bronchial responsiveness to allergy skin prick test reactivity, lung function, respiratory symptoms, and diagnoses in 13-year old Zealand children. J Allergy Clin Immunol 1995;**95**:548–556.

37. International Rhinitis Management Working Group. International consensus report on the diagnosis and management of rhinitis. Allergy 1994;**49**(Suppl. 19):1–34.

38. Gioulekas D, Chatzigeorgiou G, Lykogiannis S, Papakosta D, Mpalafoutis CH, Spieksma F. Clinical and aerobiological significance of cypress, olive and grasses pollen in Thessaloniki. Iatriki 1992;**62**:375–381.