

Airborne Pollen Concentrations and the Incidence of Allergic Asthma and Rhinoconjunctivitis in Northern Italy from 1992 to 2003

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Key Words

Aerobiology · Asthma · Pollen · Rhinitis ·
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Abstract

Background: Aeroallergens and the environment play an important role in the pathogenesis of respiratory allergies. In a 12-year study carried out in Northern Italy (geographic area of Parma), the effects of airborne pollen and meteorological conditions on the incidence of allergic asthma and rhinoconjunctivitis were evaluated. **Patients and Methods:** Among 9,060 subjects examined for respiratory pathologies at our Allergy Unit, Parma Hospital, Italy, from 1992 to 2003, only 1,054 positive to only one type of inhalant allergen in the skin prick test were studied, to avoid bias of cross-reactivity. Allergy and clinical aspects were compared with the duration of the pollination period, and peaks and total concentrations of airborne pollen. **Results:** Our data showed a significantly growing trend of allergy to mites, pets and birch pollen and a significant increase in asthma, and a significantly decreasing trend of positive reactions to grasses and a decrease in rhinoconjunctivitis. At the same time, there was a significant decrease in total pollen counts, concentration peaks and pollination period of grasses. A significant increase was only observed in ragweed and ash-olive total and peak pollen concentrations. **Conclusions:** Significant correlations between the increasing incidence in asthma and al-

lergy to mites, pets and birch pollen are shown. The decrease in the total pollen count and concentration peaks of grass pollen was correlated to the decreasing trend of rhinoconjunctivitis. The trend of increasing concentrations of ash-olive and ragweed pollen was not accompanied by an increase in the related allergy.

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Introduction

In the last 30 years, many epidemiological studies have identified a worldwide increase in allergic respiratory diseases [1–3]. This outcome has been mainly attributed to improved hygiene standards (hygiene hypothesis) [4], changes in exposure to environmental risk factors and the increasing tendency, particularly in the westernized lifestyle, to live in heated and air-conditioned environments where minimal air exchange with the outdoor environment occurs [5]. Changes in climate [6] following direct or indirect anthropological actions [7–8] have also modified plant characteristics and their distribution; moreover, changes in the weather have affected pollen distribution and the length of pollination periods. Air pollution can influence the allergenic content of plants causing modifications in pollen production and allergenic proteins of pollen grains [9]. In addition, the interaction with microparticles from heavy traffic could modify

the antigenicity of pollen content [10]. Many studies have been published on pollen and molds in the atmosphere, mites and animal antigens in domestic environments (indoor), and related allergies [11–14]. However, only short-term studies on airborne allergens [15–19] have been performed in the geoclimatic area of the Po valley (Northern Italy), without detailed correlations with respiratory diseases. In this area (city and province of Parma, south of the river Po), grasses, the most frequent cause of seasonal allergy, reach concentration peaks of 700 pollen/m³ air. Birch and cypress show concentration peaks of 150 and 200 pollen/m³ air, respectively. Ragweed, a non-indigenous pollen, comes from a nearby region (Lombardy) situated to the north of the Po, where it has been present for many years [20].

To increase this knowledge, we studied patients examined in the last 12 years at our Allergy Unit, Parma Hospital, who were suffering from rhinoconjunctivitis and/or asthma and were positive to only one allergen type in the skin prick test (SPT). Results were correlated with airborne pollen concentrations, concentration peaks and pollination periods detected and monitored over the same period.

Patients and Methods

Patients

The study was conducted from the 1st of January, 1992, to the 31st of December, 2003, in 9,060 patients (mainly adults) living in the city or province of Parma. They had a seasonal occurrence of respiratory symptoms indicating rhinoconjunctivitis and/or asthma or worsening of their disease irrespective of the season and were referred to the Allergy Unit of the Parma Hospital by their general practitioners. A detailed clinical history was obtained, and a complete physical examination was carried out for each patient. Asthma was diagnosed according to the guidelines of the Global Initiative for Asthma by clinical and functional characteristics [21]. The diagnosis of rhinoconjunctivitis was made according to a patient's clinical history and international guidelines [22]. Of these, 5,759 (63.6%) were positive to the SPT for inhalant allergens. The SPT was carried out using ALK-Abello SpA diagnostic allergens, which were either isolated – plantain, wall pellitory, cypress and olive pollen, and mold (*Alternaria tenuis*) – or in groups – grass family [orchard grass (*Dactylis glomerata*), meadow fescue (*Festuca pratensis*), Italian ryegrass (*Lolium perenne*), timothy grass (*Phleum pratense*), Kentucky blue grass (*Poa pratensis*), composite family (ragweed and mugwort), birch family (birch-alder-hazelnut), house dust mites (*Dermaphagoides farinae* and *pteronyssinus*), and pets (cat and dog). The family (group) allergens were nonetheless considered as a single diagnostic extract. Histamine chloride at 10 mg/ml and glycerol-saline solution were used as positive and negative controls. The tests were carried out on the volar side of the forearm with prick lancets (Dome-Hollister-Stier); one sterile device was

Table 1. Allergic monosensitized patients (n =1,054) to different allergens

Allergens	n	%	Allergens	n	%
Mites	533	50.6	Birch family	33	3.1
Grasses	311	29.5	Composite family	20	1.9
Wall pellitory	54	5.1	Cypress	12	1.1
Pets	50	4.8	Olive	4	0.4
Molds	33	3.1	Plantain	4	0.4

used for each test [23]. After 15 min, weal diameters >3 mm, compared with positive and negative controls, were considered positive.

Out of 5,759 positive subjects, to avoid bias caused by cross-reactivity, only 1,054 (18.3%) allergic monosensitized nonsmoking patients positive to only one type of diagnostic extract in the SPT (table 1), with a precise correlation between positivity and clinical symptoms, were included in this study (509 men and 545 women, mean age 31.5 years, range 4 and 75 years).

Aerobiological Data

We checked aerobiological data regarding total and peak pollen concentrations, and pollination period recorded in the same period. The monitoring of pollen was performed at our survey center (Italian Center: PR1) in accordance with standard methods of the Italian Aerobiology Association, now also recognized as: UNI 11108. Airborne pollen was collected using a Burkard 7-day-recording volumetric spore trap, standard equipment used for aerobiological sampling worldwide. This spore trap was placed 20 m above ground level on the meteorological tower of the University of Parma in Parma's center near the old Ducal Park. The city of Parma, with 180,000 inhabitants, lies in the Po valley, to the South of the river Po, 100 km from the Tyrrhenian coast and 200 km from the Adriatic coast (52 m above sea level, latitude 44°48' and longitude 10°16'). The choice of pollen types was based upon two criteria: (1) they had to be present in the atmosphere, every year or in recent years, in relatively high or significant concentrations, and (2) they had to be the most important allergenic pollen types causing sensitization and allergic symptoms in the people living in this region. For each taxon, 52 mean weekly pollen concentration values and peaks (pollen/m³ air) were recorded and the sum of 52 weekly pollen concentration values gave an estimate of the annual amount of each pollen type. The pollination period was calculated considering the time in which the pollen count registered between 5 and 95% of the annual total figure [24].

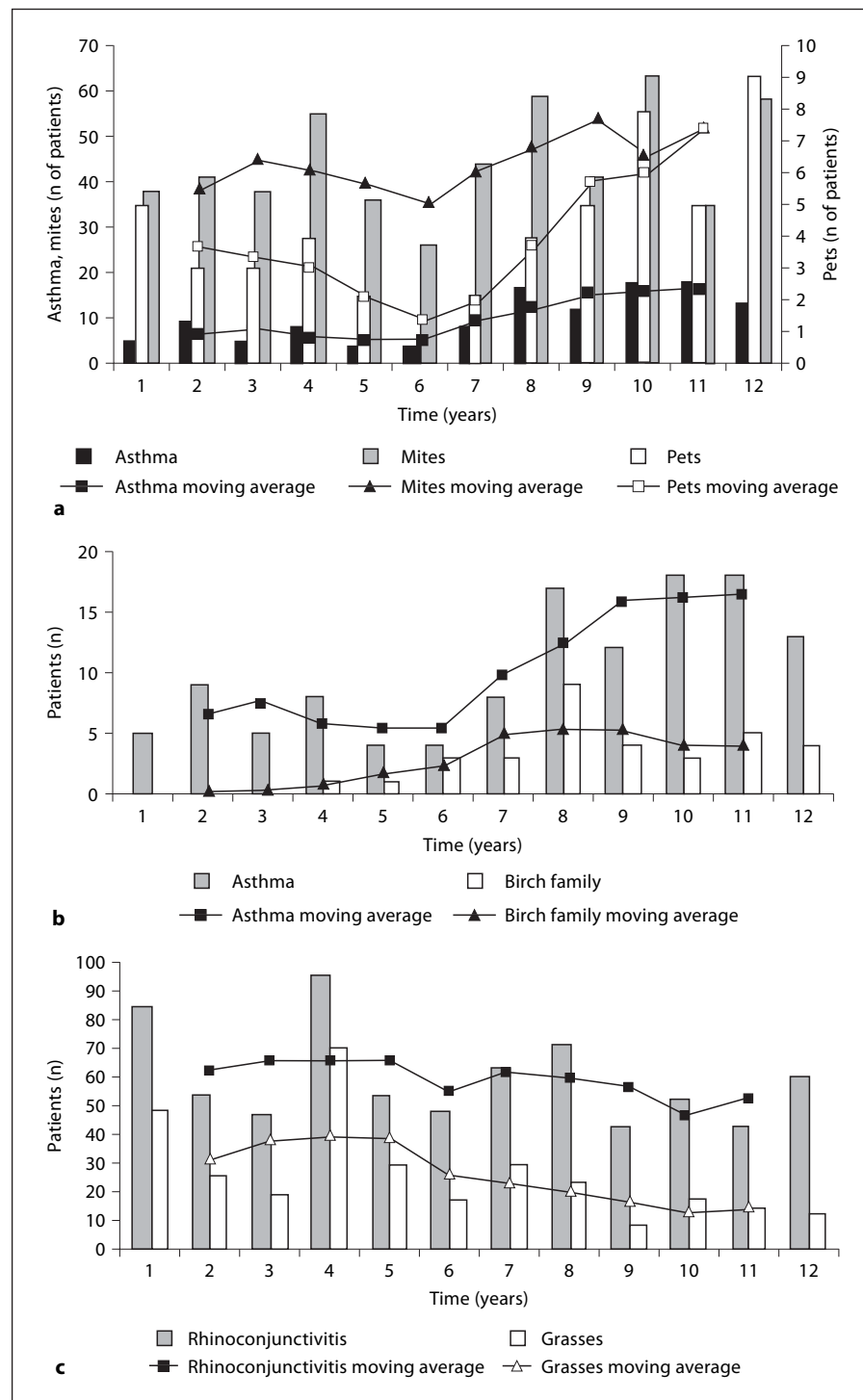
Meteorological Data

Average data on annual temperature (°C) and total rainfalls (mm rain) were obtained from the Meteorological Station (Department of Physics) at the University of Parma.

Statistics

In order to detect the existence of significant statistical trends in investigated data from 1992 to 2003, the nonparametric Cox-Stuart test was used. Kendall's 'τ' and Spearman's 'ρ' correlation tests were used to determine possible correlations between the

Fig. 1. Data of monosensitized patients from 1992 to 2003. Significant trends of SPT positivity and asthma (Cox-Stuart $n = 6$, $r = 0$, $p = 0.016$). **a** Significant positive correlation (Kendall's τ and Spearman's ρ , $n = 12$, one tailed) between: asthma and mites, $\tau = 0.536$ and $p = 0.009$, $\rho = 0.578$ and $p = 0.024$, and asthma and pets $\tau = 0.590$ and $p = 0.006$, $\rho = 0.724$ and $p = 0.004$. **b** Asthma and birch pollen, $\tau = 0.484$ and $p = 0.02$, $\rho = 0.645$ and $p = 0.012$. **c** Rhinoconjunctivitis and grasses, $\tau = 0.625$ and $p = 0.003$, $\rho = 0.759$ and $p = 0.002$.



parameters. Moreover, the Kolmogorov-Smirnov test was used on two independent samples to analyze the age distribution of monosensitized patients. They tend to be significant considering the fact that the samples are small and the Bonferroni principle is used for multiple comparisons [25].

The tests are performed using SPSS software.

Results

Of the monosensitized subjects (mean age 31.5 years), 350 cases (33.2%) were 20–30 years old. Over the 12-year examination period, we observed a significant statistical

Table 2. Pollen counts in the atmosphere of Parma from 1992 to 2003

Pollen family	Pollen counts pollen/m ³	% of total	Pollen family	Pollen counts pollen/m ³	% of total
Urticaceae	302,322	35.7	Betulaceae	26,815	3.1
Graminaceae	148,263	17.5	Compositae	14,136	1.7
Fagaceae	55,180	6.5	Oleaceae	5,724	0.7
Platanaceae	47,426	5.6	Aceraceae	14,694	2
Salicaceae	38,191	4.5	Pinaceae	14,451	1.7
Cupressaceae	37,389	4.4	Plantaginaceae	6,879	0.8
Corylaceae	35,604	4.1	Others	99,250	11.7

increase in the average annual age ($p < 0.05$) of these subjects, from of 28.33 to 34.57, as a moving average. No difference was observed between the two sexes. At the time of examination, 713 subjects (67.6%) presented with rhinoconjunctivitis, 220 (20.9%) with rhinoconjunctivitis and asthma, and 121 (11.5%) with asthma alone. Asthma was intermittent or mild-persistent according to the guidelines of the Global Initiative for Asthma [21]. Regarding the variation in these pathologies over the 12-year study period, the incidence of asthma significantly increased ($p < 0.05$) from 6 to 15.3 patients/year, as a moving average (fig. 1a), with a nonsignificant reduction in rhinoconjunctivitis. Evaluating the differences in sensitization to the various allergens during the study period, we observed a significant increase in the average number of allergic patients/year [$p < 0.05$] mites: from 39.0 to 52.0; pets: from 2.7 to 7.3 (fig. 1a), and birch pollen: from 0 to 4.0 (fig. 1b)], and a significant reduction ($p < 0.05$) in patients allergic to grass pollen (from 30.7 to 14.3), as a moving average (fig. 1c).

Comparing these variations in positive reactions with those of the clinical symptoms, we found positive correlations between the increase in allergy to mites and pets ($p < 0.01$, one tailed) and to birch pollen and the higher incidence of asthma, as well as between the decrease in allergy to grass pollen and the decrease in rhinoconjunctivitis (fig. 1). Percentages of the total pollens counted in the atmosphere of Parma are listed in table 2.

Over the 12 years, we observed a significant reduction ($p < 0.05$) in the total (from 21,240 to 8,980 pollen/m³) and peak concentration (from 5,232 to 1,934 pollen/m³), and in the pollination period (from 13.3 to 10.7 weeks) for grasses, and also in the peak concentration of poplars and willows (from 2,547 to 676.6 pollen/m³).

A significant increase ($p < 0.05$), however, was observed in the total and peak pollen concentrations for the ash-olive family (from 163.0 to 787.3 and from 33.3 to 164.0 pollen/m³, respectively) and ragweed (from 0.7 to 293.7 and from 0.3 to 44.0 pollen/m³, respectively; fig. 2). A positive correlation was observed only for grasses between the decrease in the total and peak concentrations ($p < 0.05$) and the pollination period ($p < 0.01$) and the decrease in specific allergy. Regarding meteorological data, a nonsignificant increase in the mean temperature, from 14.2 to 14.6°C, as a moving average, was observed. The total rainfall showed a nonsignificant decrease from 838.2 to 723.1 mm, as a moving average, for the period observed.

Discussion

Aeroallergens play an important role in the pathogenesis of seasonal allergic respiratory diseases. The role and importance of different pollen allergens can change according to environmental conditions, e.g. climate, pollution and degree of exposure. Pollen calendars are very useful for clinicians as well as allergic patients to understand and establish chronological correlations between the seasonal concentration and allergic symptoms and the different airborne pollen. In keeping with other studies [26], our investigation reported an increase in pollen concentrations of olive and ragweed, which are non-indigenous in our geoclimatic zone, and a decrease in the pollen concentrations of indigenous grasses. This trend appears as a consequence of the increase in non-indigenous trees growing in parks and avenues, in private gardens or in forest conservation areas, and a grass pollen decrease resulting from urban sprawl and the progressive reduction in cultivated areas, such as permanent lawns

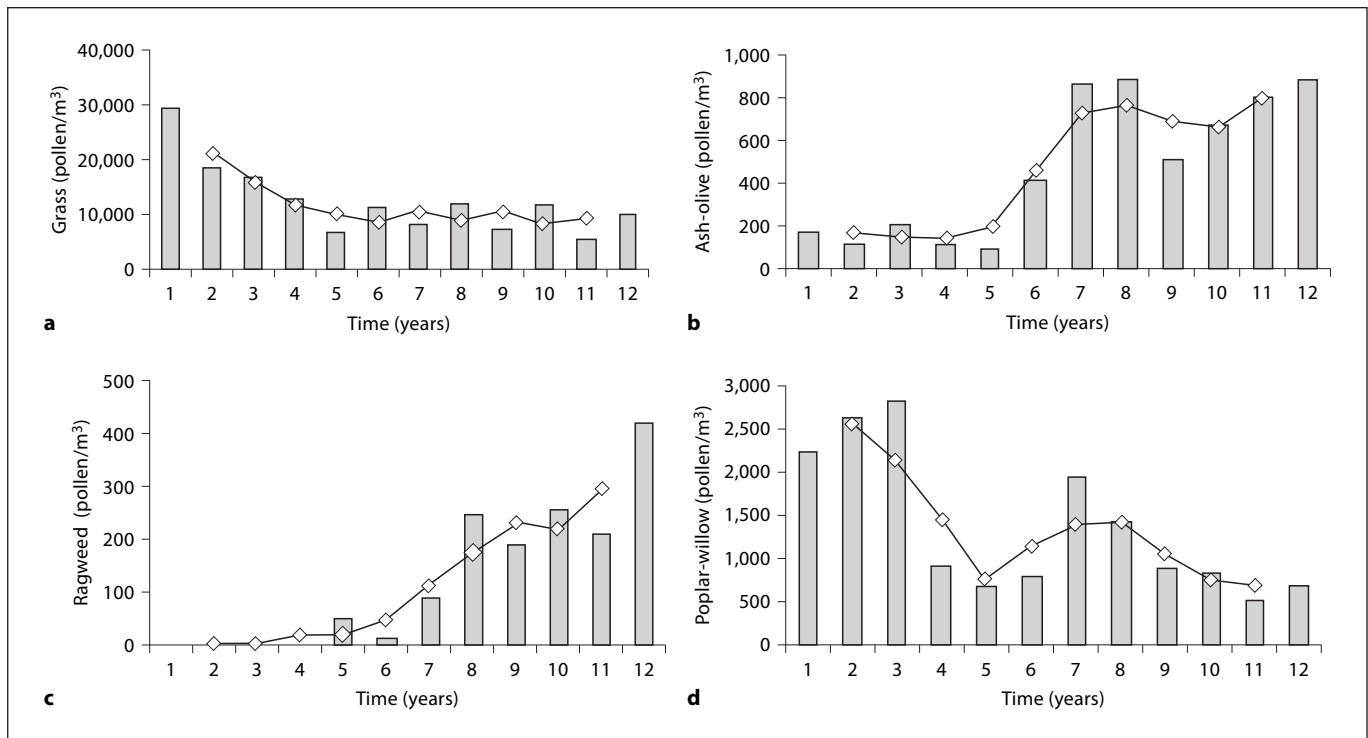


Fig. 2. Significant positive and negative trends in atmospheric pollen counts in Parma as a moving average, from 1992 to 2003 (Cox-Stuart $n = 6$, $r = 0$, $p = 0.016$). **a–c** Total counts. **d** Peak.

and pastureland, by 34.9% from 1990 to 2000 in this geographic area [27] and, in part, also of global atmospheric changes [28], such as the trend of an increase in the annual temperature observed. Moreover, direct anthropological impact by the introduction of non-indigenous species, such as birch, olive and Arizona cypress, in our geoclimatic areas, has caused an increase in 'new' allergies. Urticaceae represent the most frequent pollen in our records, most likely due to the high presence of nettles in uncultivated areas in the nearby Ducal Park, without variations over time, with a low incidence of monosensitized allergic subjects to wall pellitory (5.1%). However, among herbaceous plants, only the concentration of non-indigenous ragweed revealed a significant increase in total and peak pollen concentrations with a nonsignificant increase in pollination period. Concerning the clinical aspects of our research, the highest allergy incidence in our monosensitized patients was to mites. Grass pollen, which had been the most significant cause of allergic respiratory disease in our previous studies [29] on mono- and polysensitized subjects, was a less frequent cause (29.5%) in this study on monosensitized patients. Many

epidemiological investigations have shown that allergy to tree pollen has become more significant during recent years, with a contemporary decrease in allergy to grasses or other herbaceous pollen, with the exception of ragweed in some regions [30]. These observations were also confirmed in our study. In fact, aerobiological analysis showed a decrease in total and peak pollen concentrations, and pollination period coupled with a parallel decrease in allergy and a significant increase in total and peak pollen concentrations of ragweed. However, although being nonsignificant, allergy to birch pollen has increased, while the significant increase in ash-olive and composite pollen concentrations was not accompanied by a rise in the allergy. One hypothesis for this phenomenon could be that the birch family has been present in our province for some considerable time, whereas ragweed and olive are more recent additions, thus explaining the delayed increase in these species.

It is not always easy to establish a correlation between aerobiological data, air pollution, climatic records and lifestyle factors, e.g. westernization, and changes in the distribution of inhalant allergies.

The significantly increasing incidence of allergy to mites and pets may be a consequence of an increasing tendency towards an indoor lifestyle, with reduced air exchange and use of air-conditioning. It may also be a result of the fact that the number of pets kept has gone up in line with the increase in the average age of the population, since pets may play an important therapeutic role (pet therapy) in the lives of children and in particular in the elderly [31]. For example the number of dogs registered in the municipal canine registry of Parma increased from 315.33 to 1,683 as a moving average between 1992 and 2003. Mite and pet allergens, particularly Fel d1, are more frequently a cause of asthma, most likely due to their small size. The same could be suggested for pollen, such as birch pollen, which is more frequently a cause of asthma, e.g. in Scandinavian people [30], while grass pollen is more frequently a cause of rhinoconjunctivitis. The incidence of asthma increased in our patients, probably

due to the increase in allergy to indoor allergens, in accordance with previously published studies [32, 33], while the decrease in rhinoconjunctivitis, the most frequent allergic manifestation in our patients, was probably due to a decrease in total and peak pollen concentrations, and pollen duration, mainly in grasses. Of note, there was an increase in the average age of monosensitized patients during the examination period, possibly indicating that allergy tends to occur at a more advanced age, in particular for some allergens, e.g. wall pellitory and birch pollen, being present in our area for some time.

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