Aeroallergen prevalence in the northern New Jersey–New York City metropolitan area: a 15-year summary

Ava Port, MD; John Hein, MD; Alan Wolff, MD; and Leonard Bielory, MD

Background: Elevated environmental pollen levels result in allergic and asthmatic symptoms in sensitive individuals.

Objective: To present data collected during a 15-year period demonstrating the seasonal pollen variation in a metropolitan area.

Methods: Pollen was collected daily except for weekends. Pollen counts were counted using light microscopy and were used to calculate the average daily pollen count per month between March 1 and October 31 of each calendar year. The month in which each class of pollen reached the highest level (peak) was analyzed across the sampling period. Spearman ρ correlation coefficients were calculated to show changes in peak pollen levels across time.

Results: The average daily pollen level (tree, grasses, and weeds) for each month was analyzed (1987–2002). Tree pollen peaked in May and composed 98.7% of the measurable pollen between March and May. Grass pollen had a biphasic peak (June and September), representing 42.9% of measurable pollen in July and 6.4% in September. Weed and ragweed levels peaked in September. Total weed pollen constituted 93.5% of the measurable pollen between August and October. The combined total pollen levels peaked in May. The highest annual peak tree pollen count was observed between 1992 and 1997, with a linear relationship between tree and total pollen ($R^2 = 0.97$); highest levels of grass pollen were observed between 1993 and 1997; and highest levels of weed pollen were observed between 1993 and 1995. A trend toward declining levels of total pollen was observed between 1993 and 2002. This declining trend was most pronounced for weed pollen.

Conclusions: Aeroallergens pollinate sequentially, starting with trees in the spring, grass throughout the summer, and weeds in late summer to early fall. Pollen levels have declined from 1993 to the present. The most pronounced drop has been in weed pollen levels. Grass pollen demonstrates a biphasic pattern. Tree pollen composes most annual pollen measured in the northern New Jersey–New York City area.

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INTRODUCTION

Elevated pollen levels result in various forms of IgE-mediated disorders in the general population, including asthma, rhinitis, and ocular allergy.[1] These type I hypersensitivity reactions occur immediately after contact with otherwise harmless environmental antigens, such as pollen or mold.[1,2] Pollen, the male gametophyte of seed-bearing plants, resembles a fine dust of allergenic particles. Wind is a major mechanism for pollen distribution, carrying pollen grains great distances to perform their essential role in fertilization. Consequently, plants produce large volumes of pollen to ensure the spread of their genetic material and, therefore, are a significant source of airborne allergens (aeroallergens).[3] Aeroallergen sampling provides information that is clinically beneficial in determining the possible cause of allergic symptoms in sensitive individuals.

New Jersey is the fourth smallest state in the United States, covering a total area of 7,787 square miles. The state has 319 square miles of water surface area, bounded on the west by the Delaware River and on the east by the Hudson River and the Atlantic Ocean. The state is separated into 3 physical divisions, including the mountainous northern Appalachian Highlands, the urban central Triassic section, and the large southern Coastal Plain.[4] In this study, pollen was collected in the city of Newark, which resides in the Triassic division of New Jersey, approximately 10 miles west of New York City, NY, where predominating winds are directed toward the east. Pollen grains can remain airborne for many miles; thus, samples taken from this site represent allergens that affect the entire New York City metropolitan area. In New Jersey, sequential release of tree, grass, and weed pollens between February and November have been described.[5,6] This study confirms the seasonal pollen variation in the northern New Jersey–New York City (NNJ/NYC) metropolitan area and demonstrates a downward trend in the average peak pollen levels from 1993 to 2002.

Division of Allergy, Immunology, and Rheumatology, University of Medicine and Dentistry of New Jersey–New Jersey Medical School, Newark, New Jersey.

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METHODS

Pollen counts were performed in Newark by trained individuals at the University of Medicine and Dentistry of New Jersey Asthma and Allergy Research Center. Pollen was sampled from air using a volumetric sampling device (model

40 Rotorod; SDI Co, Plymouth Meeting, PA) during a 24-hour period according to the National Allergy Bureau duty cycle. This device was returned to the manufacturer every 2 years for calibration and testing to ensure accurate counts across time. Lucite rods coated in silicone grease were rotated at a fixed speed for 30 seconds every 10 minutes during a 24-hour interval. The rods were removed, and the pollen grains were visualized and counted across a fixed distance using Calberla stain and light microscopy (magnification ×40). Pollen counts were obtained between March 1 and October 31 of each calendar year (1987–2002). Counts were performed daily at 8 AM, except Saturday and Sunday. A Monday reading represented the total collection of pollen from Friday (8 AM) through the weekend until Monday (8 AM). Therefore, the Monday count was the average of 3 days (Friday, Saturday, and Sunday) and was divided by 3 to yield the average daily count for the weekend. Daily pollen counts were used to calculate the average daily pollen count per month by dividing the raw sum of total pollen grains by the corresponding number of total days. Data were reported as the average number of pollen particles per cubic meter per day of air sampled.[7,8] Although each species of tree and weed pollen was identified and counted individually, only analyses of average pollen totals are reported in this study.

Pollen levels were examined to determine whether trends existed across time. The month in which each class of pollen reached the highest level was analyzed across the sampling period. This month was designated as the peak for each calendar year. Spearman ρ correlation coefficients were calculated using statistical software (SPSS; SPSS Inc, Chicago, IL) to show changes in peak pollen levels across time.

RESULTS

The 3 major classes of pollen identified were tree, grass, and weed. The expected pattern of sequential pollen release for this region of the United States was observed: trees pollinate during spring; grasses between spring and early summer, with a second wave observed in September; and weeds between late summer and early fall (Fig 1). Tree pollination occurs predominantly between March and June of each calendar year (Fig 1A). Tree pollen levels peaked in May, with an average daily pollen count for the 15-year study period of 990 grain/m^3 (95% confidence interval [CI], −213 to 2,193 grain/m^3; median, 709 grain/m^3). Trees compose 78.2% (1,641/

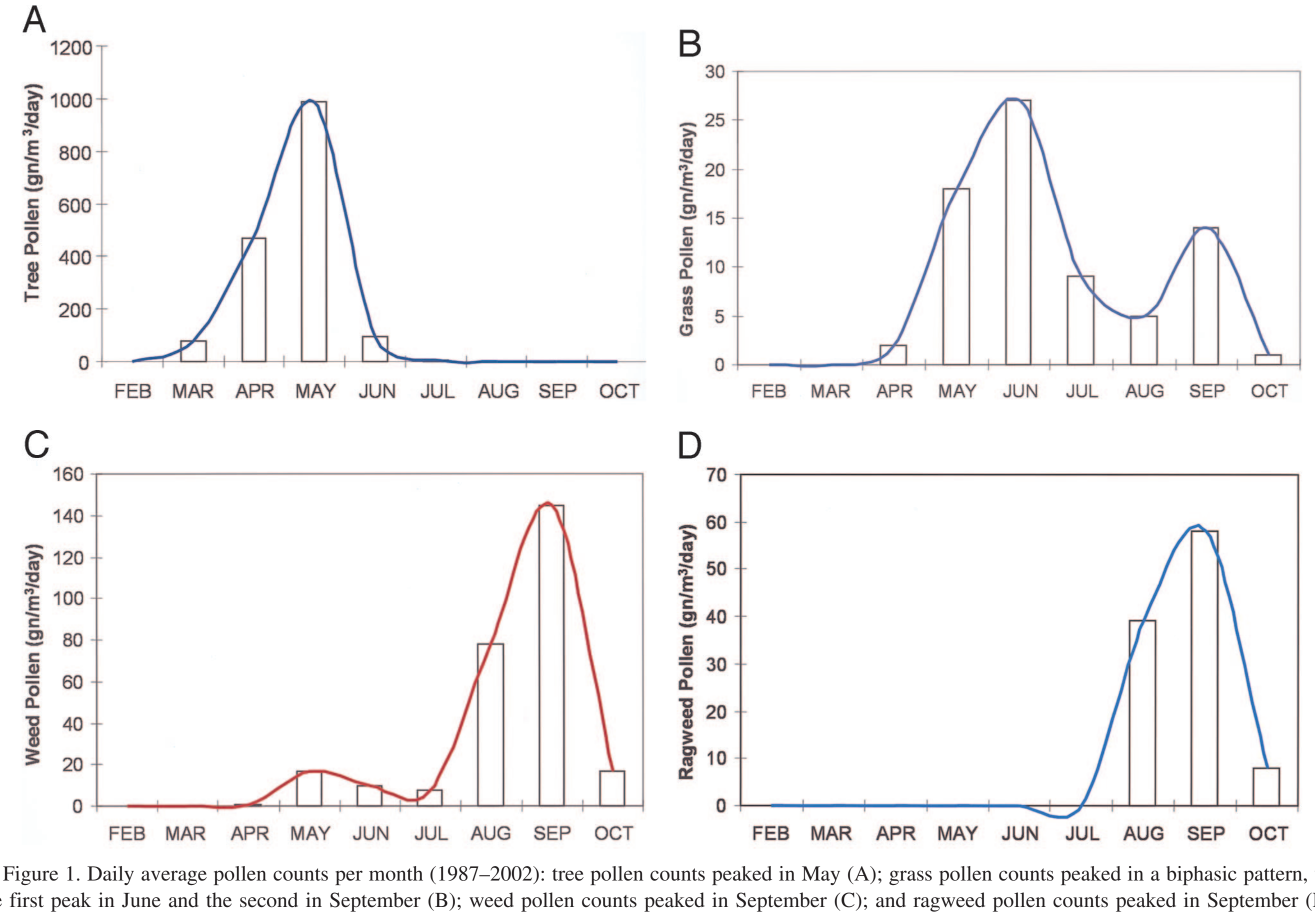

Figure 1. Daily average pollen counts per month (1987–2002): tree pollen counts peaked in May (A); grass pollen counts peaked in a biphasic pattern, with the first peak in June and the second in September (B); weed pollen counts peaked in September (C); and ragweed pollen counts peaked in September (D).

2,098 grain/m^3 per day) of the total measurable pollen load throughout the year and 97.6% (1,540/1,578 grain/m^3 per day) between March and May (Table 1). There was a linear relationship between tree pollen and total pollen ($R^2 = 0.97$). Tree pollen identified included alder (*Alnus* species), ash (*Fraxinus* species), beech (*Fagus* species), birch (*Betula* species), cottonwood (*Populus* species), elm (*Ulmus* species), hickory (*Carya* species), oak (*Qeurcus* species), maple (*Acer* species), sweetgum (*Liquidambar* species), sycamore (*Plantanus* species), and walnut (*Juglans* species). Individual species counts were not examined in this analysis.

Release of grass pollen was observed between May and July and again in September (Fig 1B). Grass pollen had a biphasic peak, with the first peak appearing in June (27 grain/m^3 per day; 95% CI, 0 to 54 grain/m^3 per day; median, 28 grain/m^3 per day) and the second in September (14 grain/m^3 per day; 95% CI, −1.7 to 22.7 grain/m^3 per day; median, 10 grain/m^3 per day). Grasses constituted 3.6% (76/2,098 grain/m^3 per day) of the total annual pollen load (Table 1).

Weed and ragweed pollen both peaked in September at 145 grain/m^3 per day (95% CI, −55 to 345 grain/m^3 per day; median, 146 grain/m^3 per day) and 58 grain/m^3 per day (95% CI, 5.3 to 110.7 grain/m^3 per day; median, 49 grain/m^3 per day), respectively (Fig 1 C and D). Weeds composed 13.2% (276/2,098 grain/m^3 per day) of the total annual pollen load. Weed species included wormwood (*Artemisia* species), lamb's quarters (*Chenopodium* species), English plantain (*Plantago* species), pigweed (*Amaranthus* species), sorrel/dock (*Rumex* species), cattail (*Typha* species), and nettle (*Urtica* species). Ragweed (*Ambrosia*) composed 5.0% (105/2,098 grain/m^3 per day) of the total annual pollen load (Table 1) and was analyzed separately from the other weed species.

Annual peak pollen levels revealed that the highest levels of tree pollen were observed between 1992 and 1997. The highest levels of grass pollen were observed between 1993 and 1997, and the highest levels of weed pollen occurred between 1993 and 1995. A statistically significant decrease in peak pollen levels was observed between 1993 and 2002. This trend was noticed in levels of tree, grass, and ragweed pollen but was most pronounced in levels of weed pollen (Fig 2).

Table 1. Average Counts of the Various Pollens by Month

Month	Pollen count, grain/m^3 per day				
	Trees	Grasses	Weeds	Ragweed	Total
March	79	0	0	0	**79**
April	471	2	1	0	**474**
May	990	18	17	0	**1,023**
June	93	27	10	0	**128**
July	4	9	8	0	**19**
August	1	5	78	39	**83**
September	2	14	145	58	**165**
October	1	1	17	8	**19**

DISCUSSION

Pollen-producing plants can be categorized as either anemophils (wind pollinating) or entemophils (insect pollinating). Although pollen is produced by a variety of plants, not all pollen molecules can induce an allergic reaction. The plant species responsible for causing the greatest atopic responses are typically anemophilous, which includes trees, grasses, and weeds. Aeroallergens are not required in large quantities to trigger a response; in fact, seasonal allergies are generally the result of repeated inhalation of low doses of airborne pollen.[9,10] This is demonstrated by the fact that ragweed pollen is released into the atmosphere in relatively minute amounts compared with tree pollen and yet many allergic patients are sensitive to it.[11] In fact, most people with seasonal allergy throughout the United States are sensitive to grasses and weeds, although they account for a small amount of the total pollen load.[12]

Typical atopic diseases, such as allergic rhinitis, allergic conjunctivitis, and extrinsic asthma, are often induced by contact between aeroallergens and mucosal surfaces.[13] Aeroallergens are complex moieties that contain antigenic protein components that lead to activation and degranulation of mast cells by specific IgE and, hence, the release of inflammatory mediators that generate a characteristic allergic response.[3,14] Pollen is one of the most common aeroallergens subject to seasonal variation. Therefore, it is important that physicians who treat patients with allergic conditions are knowledgeable about the timing of local and regional pollen seasons. In this study, pollen from the NNJ/NYC metropolitan area was examined across a 15-year period, and the timing of species-specific pollination in the New Jersey environment was documented.

Studies[3,6,15] have shown that although most airborne pollen grains fall within 100 m of their source, particles can travel quantifiable distances of several hundreds of miles by wind. One study showed negligible differences in pollen trends, other than species-specific changes, between Cherry Hill, NJ, and Philadelphia, PA, 2 major cities separated by approximately 10 miles and the Delaware River. Similarly, New York City and Newark are approximately 10 miles apart and are separated by water (Hudson River/New York Harbor). Therefore, readings taken in Newark can be used to describe trends in and levels of aeroallergens in the greater NNJ/NYC area.

Quantification of pollen counts may be used to describe pollen levels as being low, moderate, high, or very high. Burge[16] classified pollen counts as follows: trees (0–15, >15–90, >90–1,500, and >1,500 grain/m^3), grasses (0–5, >5–20, >20–200, and >200 grain/m^3), and weeds (0–10, >10–50, >50–500, and >500 grain/m^3). Pollen counts exceeding 10 grain/m^3 are considered significant. This study demonstrates that in the NNJ/NYC area, tree pollen reaches high levels in April, May, and June (471, 990, 93 grains/m^3 per day, respectively). The 2 most prevalent pollen-producing genera are elm (*Ulmus* species) and birch (*Betula* species).[12]

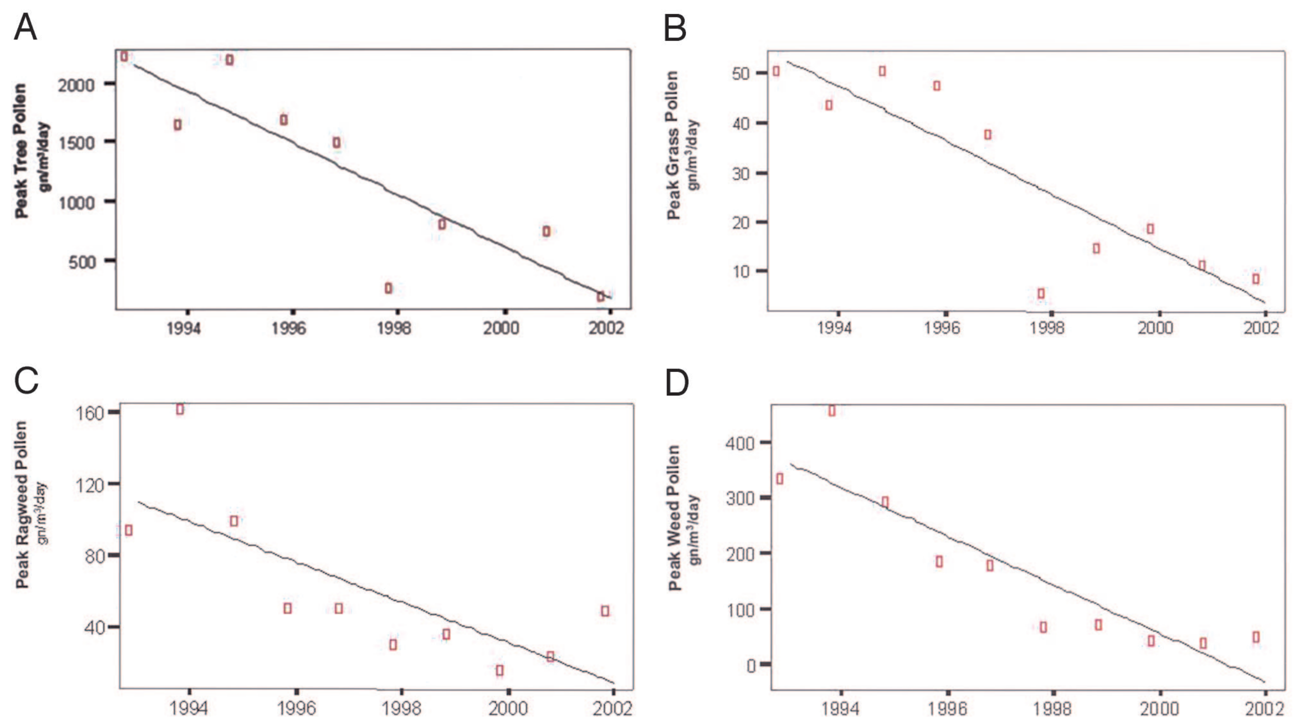

Figure 2. Declining tree (A) (0.900, $P = .001$); grass (B) (-0.821, $P = .004$); ragweed (C) (-0.815, $P = .004$); and weeds (D) (-0.939, $P = .001$). The statistics are presented as Spearman ρ correlation coefficients with P values (2-tailed).

Pollen is morphologically unique to each tree genus, and, hence, variations in allergenicity exist. Furthermore, although most trees are similar in duration of the pollinating period, they differ in the timing of their initial pollen release.[12]

Grass pollen is first detected in April and reaches high levels in June (27 grain/m^3 per day). Counts remain at moderate levels throughout the summer, with a second peak in September (14 grain/m^3 per day). Because it is difficult to distinguish grass pollen based on its morphology, it is unclear whether this second pollination is species specific. In the NNJ/NYC metropolitan area, the major grass species include blue (*Poa pratensis*), orchard (*Dactylis glomerata*), timothy (*Phleum pratense*), and red top (*Agrostis alba*). Grasses are the second major cause (after weeds) of seasonal allergic symptoms in the NNJ/NYC area and throughout the United States, and they contribute to significant problems in the rest of the world.[2,11]

Weeds pollinate throughout the summer and reach high levels in August and September (78 and 145 grain/m^3 per day, respectively). Ragweed counts are moderate in August (39 grain/m^3 per day) and high in September (58 grain/m^3 per day). Although many native weed species, including sorrel (*Rumex* species), lamb's quarters (*Chenopodium* species), and plantain (*Plantago* species), are problematic for allergy patients, none of these weeds can cause a reaction clinically equivalent to ragweed (*Ambrosia* species).[17] Ragweed is the most significant cause of seasonal allergic rhinitis in the United States, qualitatively and quantitatively.[4,17]

Total pollen levels have declined in the NNJ/NYC area from 1993 to the present. This decline may be due to increased urbanization, leading to less acreage for vegetation to grow, thus decreasing the number of pollen-producing plants. This theory is in contrast to previous observations that ragweed biomass increases with increased urbanization.[18] There may be climatic variables or changes in soil composition that have accounted for this decline. These factors should be the subject of future study.

Prediction of daily pollen levels using modeling systems is challenging owing to the extraordinary complexity of the relationships among the environmental factors (wind, rainfall, and temperature) that affect its spread. Long-term trends are useful in advising patients of when to expect symptoms and to participate in preventive measures such as avoidance of outdoor exposure or treatments such as immunotherapy or pharmacotherapy. However, daily pollen counts cannot be directly correlated to allergic symptoms because allergic individuals vary in their sensitivity; therefore, clinicians must interpret such information cautiously.

CONCLUSIONS

Tree pollen composes most of the annual pollen measured in the NNJ/NYC area. Tree pollination predominantly occurs from March through June, with peak pollination occurring in May. Grass pollination begins as early as April and tapers off in October. Grass pollen exhibits a biphasic pattern, with the major peak occurring in June and the minor peak in September. Weed pollination also begins as early as April and throughout October. The peak weed pollen season is in September, corresponding to a peak in ragweed levels. Total pollen levels are at their highest in May, coinciding with the peak in tree pollen levels. Total pollen levels have declined since 1993. The cause of this decline is unclear and is the subject of future study.

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Requests for reprints should be addressed to:
Leonard Bielory, MD
Division of Allergy, Immunology, and Rheumatology
University of Medicine and Dentistry of New Jersey–New Jersey Medical School
90 Bergen St, Suite 4700
Newark, NJ 07103
E-mail: bielory@umdnj.edu