

Effect of tree and grass pollens and fungal spores on spring allergic rhinitis: a comparative study

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Background: Current literature indicates tree pollen is less important than grass pollen as the cause of spring allergic rhinitis. The role of fungal spores is secondary and uncertain.

Objective: To assess the relative allergenicity of tree and grass pollen and fungal spores as the cause of spring allergic rhinitis in central Indiana.

Methods: (1) Chart review of 189 Indiana natives with seasonal allergic rhinitis to ascertain clinical sensitivity to tree or grass pollens. (2) A prospective study conducted in the spring of 1997 in 51 patients, correlating patients' symptom and medication scores with daily pollen and spore counts, obtained with a Burkard spore trap.

Results: One hundred thirty of 189 patients (69%) reported symptoms before May with positive prick test to at least one tree pollen. One hundred thirty-four patients (71%) had symptoms in May and June with positive test to grass pollen. The ratio between the two groups is 1:1, in contrast to a ratio of 1:4 derived from the literature. The prospective study revealed a symptom score increase parallel to the rise of tree pollen counts beginning in mid-March and reaching a plateau in early May prior to the onset of grass season. Medication use continued to increase and peaked at the height of grass pollination. Spore counts increased in late May and stayed at high levels throughout June, yet symptom and medication scores steadily declined following the peak of grass pollination in early June.

Conclusions: This study suggests that in central Indiana, tree pollen is more important as the cause of spring allergic rhinitis than that suggested by the literature. This study confirmed previous observations that fungal spores are substantially less allergenic than pollens.

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INTRODUCTION

It has long been established that pollen is the primary cause of seasonal allergic rhinitis.¹⁻³ Fungal spores are secondary and their role is not certain.⁴⁻⁶ Estimates of pollen-induced rhinitis

cited in the current literature are as follows: tree pollen 9%, grass pollen 40%, and ragweed pollen 75%.⁷⁻⁹ The ratio of the frequency of tree sensitivity to the frequency of grass sensitivity in patients with pollen-induced rhinitis is approximately 1:4. In central Indiana and in much of the agricultural region east of the Rocky Mountains there is no question about the primary importance of ragweed pollen as the cause of late summer seasonal allergic rhinitis. In Indiana, both trees and

grass pollinate in the spring with significant overlap.¹⁰ Pollen surveys in this area, as well as in similar geographic locations, reveal an overabundance of tree pollens compared with grass pollens. Allergy skin testing also reveals a high incidence of positive reactions to tree pollens.¹⁰ These observations suggest that tree pollen allergy is common and that there is a higher incidence of tree pollen-induced rhinitis, at least in central Indiana, than that suggested by the literature.

In recent years, under the initiative of the Aeroallergen Network (sponsored by the American Academy of Allergy, Asthma and Immunology), surveying of airborne pollens and fungal spores has gained increasing popularity across the nation. Primary sampling devices include the rotorod sampler and the Burkard spore trap. Compared with the rotorod sampler, the Burkard spore trap is more efficient in capturing smaller fungal spores ($<10 \mu\text{m}$) and provides a better representation of the entire spectrum of recognizable outdoor aeroallergens which range in size from 2 to 50 μm .^{5,11,12}

The purpose of this study was to compare the relative allergenic importance of tree and grass pollens and fungal spores as the cause of spring allergic rhinitis in central Indiana. We analyzed a population of Indiana natives who had seasonal allergic rhinitis in terms of timing of symptom presentation and skin test results to aeroallergens present in the spring. A subset of the population was further analyzed by tabulating daily symptom scores and medication usage, comparing those results with daily pollen and

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spore counts obtained by air sampling with a Burkard spore trap.

METHODS

Patients

From 1992 through 1996, 189 consecutive patients with seasonal allergic rhinitis examined by one of the authors (LYFW) qualified for the analysis. These patients had the following characteristics (Table 1): they were Indiana natives, defined as people who were born in Indiana and had not lived out of the state for more than 3 months at a time during their lifetime. Since they had been exposed to the same outdoor aeroallergens all their lives, their seasonal allergic symptoms and skin test results should reflect the relative allergenicity of the prevailing outdoor pollen and fungal allergens. Their ages were from 9 to 57 years old. None had received immunotherapy. A battery of 63 allergens (Greer Laboratories, Inc, Lenoir, North Carolina) with one negative (saline) control and one positive (histamine base 1 mg/mL) control were administered by the prick method of Booth.¹³ A grading system of 0 to 4+ was employed with a wheal size 3

mm or greater considered to be positive (2+ or above). The extracts included those outdoor pollen and fungal allergens thought to be present in the spring (Table 2). Patients were analyzed for clinical sensitivities to tree and grass pollen: presence of symptoms prior to May with positive skin test to at least one tree pollen and presence of symptoms in May and June with at least one positive skin test to grass pollen tested.

Prospective Study

In the spring of 1997, a prospective study was conducted to compare patients' daily symptom and medication scores with daily pollen and spore counts. Subjects were recruited from five allergy practices in six locations in central Indiana. A recruitment letter was first sent out in early March, prior to the study, to patients who had a diagnosis of seasonal allergic rhinitis with symptoms that occurred in spring and/or early summer (anytime March through June). This is the time period that tree and grass pollinate in Indiana. Fifty-one patients who met the entry criteria were enrolled. Total tree and grass pollen counts, total spore counts, and those of four major fungus categories identified in air sampling (ie, *Alternaria*, *Cladosporium*, ascospores and basidiospores) were included in the analysis. The study began in mid-March and ended the last week of June.

Patients enrolled included Indiana natives who were 12 to 58 years of age, had symptoms for at least 2 years, and had positive skin test to at least one allergen listed in Table 2. Skin tests were administered and interpreted by physicians certified by the American Board of Allergy and Immunology or by their assistants in accordance with the published guidelines.¹⁴ Four participating allergists used prick technique as their primary diagnostic method, whereas one used Multi-test technique. While all used the intracutaneous method when indicated in clinical practice, those patients who were positive only by the intracutaneous tests were excluded in the present study.^{14,15} None of the patients had re-

ceived immunotherapy during the previous 12 months. Female patients were not pregnant or nursing.

Patients who had acute sinusitis or used oral steroids within 4 weeks of the initial visit were excluded. Those who had significant perennial nasal symptoms or had other nasal pathology that could affect the assessment of seasonal increase in symptoms were also excluded. All patients agreed to remain in the midwest throughout the study.

Four study visits were scheduled. The screening evaluation (visit 1) consisted of a system review, a limited physical examination, review of allergy skin test results, instruction on recording symptom and medication diary cards, and study medication distribution. Symptom recording, medication usage, and subsequent tabulation of symptom and medication scores were adapted from Schoenwetter and Lim,¹⁶ Juniper et al¹⁷ and Nelson¹⁸ with some modifications.

Symptom scores were recorded daily by patients in the evening using a four point scale: 0 for no symptoms, 1 for mild but not annoying symptoms, 2 for moderate and annoying symptoms, and 3 for severe symptoms interfering with daily activities or sleep. Symptoms assessed included itchy nose, runny nose, nasal obstruction, sneezing, and itchy eyes. Daily symptom scores represented the sum of each individual symptom. A weekly average was tabulated.

Patients were instructed to use medications only for relief of troublesome symptoms (symptom scores ≥ 2) beginning with fexofenadine HCl 60 mg (Allegra, Hoechst Marion Roussel) one capsule every 12 hours as needed. Symptoms not relieved by fexofenadine up to twice a day were treated with beclomethasone dipropionate aqueous nasal spray (Vancenase AQ 42 μ g, Schering Corporation), 2 sprays in each nostril up to twice a day. As soon as the symptoms improved, patients were asked to reduce or discontinue beclomethasone dipropionate AQ and later, fexofenadine. Eye symptoms were treated with naphazoline-pheniramine eye drops (OcuHist, Pfizer Inc. or

Table 1. Characteristics of Indiana Natives with Seasonal Allergic Rhinitis

	Number of Patients
Number	189
Age (yr)	
Mean $\pm$ SD	27 $\pm$ 9
Range	9-57
Sex	
Male (%)	88 (47%)
Female (%)	101 (53%)
Duration of rhinitis (yr)	
Mean $\pm$ SD	13 $\pm$ 11
Range	1-50
Skin prick sensitivity to	
Tree pollen	135 (71%)
Grass pollen	139 (74%)
Ragweed pollen	157 (83%)
Fungi	83 (44%)
Dust mite	89 (47%)
Cat	73 (39%)
Dog	24 (13%)
Cockroach	16 (8%)
Asthma	76 (40%)
Prior immunotherapy	None

Table 2. Pollen and Fungal Allergens Included in the Skin Testing Analysis

Cedar, <i>Juniperus virginiana</i>	<i>Alternaria alternata</i>
Elm, <i>Ulmus americana</i>	<i>Cladosporium sphaerospermum</i>
Alder, <i>Alnus rugosa</i>	<i>Stemphylium solani</i>
Maple mix, <i>Acer rubrum</i>	<i>Helminthosporium sativum</i>
<i>Acer saccharum</i>	<i>Epicoccum purpurascens</i>
Box elder, <i>Acer negundo</i>	<i>Pullularia pullulans</i>
Birch mix, <i>Betula nigra</i>	<i>Fusarium mix, F. solani</i>
<i>Betula lenta</i>	<i>F. moniliforme</i>
<i>Betula populifolia</i>	<i>Ustilago maydis</i> , (corn smut)
Poplar, <i>Populus deltoides</i>	<i>Puccinia graminis sp. tritici</i> ,
Willow, <i>Salix nigra</i>	(wheat stem rust)
Ash, <i>Fraxinus americana</i>	<i>Phoma herbarum</i>
Oak, <i>Quercus rubra</i>	<i>Curvularia spicifera</i>
Beech, <i>Fagus americana</i>	<i>Spondylocadium atrovirens</i>
Hickory, <i>Carya ovata</i>	
Pecan, <i>Carya illinoensis</i>	
Sycamore, <i>Platanus occidentalis</i>	
Walnut, <i>Juglans nigra</i>	
June grass, <i>Poa pratensis</i>	
Timothy grass, <i>Phleum pratense</i>	
Bermuda grass, <i>Cynodon dactylon</i>	

Naphcon A, Alcon Labs) one drop per eye up to four times a day. Daily medication scores represented the sum of daily medication usage with one point assigned to one dose of any medication used. A weekly average was tabulated.

The second visit was scheduled 1 to 2 weeks following the initial visit. This was to ensure accurate symptom and medication recording. The remaining two visits were scheduled 4 to 6 weeks apart with the last visit being in late June. During each visit, symptom and medication diary cards were reviewed and collected, nasal inhaler technique was reviewed, and additional medications were dispensed as necessary. A pertinent physical examination and a global assessment of symptoms were completed at each visit by the study physician.

A Burkard spore trap (Burkard Manufacturing Co Ltd, Rickmansworth, England) was installed atop an 8-story

office building which was located within the suburban area of Indianapolis, Indiana. All study sites were within a 60-mile radius of the air sampling station. Total and individual pollen and spore counts were enumerated and a weekly average of daily pollen and spore counts were expressed as particles per cubic meter of air.¹⁹ The protocol was approved by the Institutional Review Board of St. Vincent Hospital and Health Services.

Statistical Analysis

Statistical analysis of continuous variables was performed using a two-tailed t-test. Correlation of pollen and spore counts with symptom or medication scores was carried out using single regression analysis with the counts being independent variables and the symptom scores being dependent variables. Differences in symptom and medication scores through time were com-

pared using a paired t-test. All data were analyzed using the PC JMP Statistical Discovery Software (SAS Institute, Cary, NC). Probabilities $\leq .05$ were considered statistically significant.

RESULTS

Based on the history and results of their skin tests, 130 out of 189 patients (69%) were considered to be allergic to tree pollen and 134 patients (71%) to grass pollen. The ratio between the two groups was 1:1 (Table 3). A considerable overlap existed between the two groups with 108 patients (57%) being allergic to both tree and grass pollens.

The comparison of symptom scores, pollen and spore counts represented by *Alternaria* in the prospective study of 1997 is depicted in Figure 1. From mid-March through the week of May 18th, symptom scores increased parallel to the increase in tree pollen counts (correlation coefficient, $r = 0.73$, $P < .002$). Symptom scores reached a plateau in the week of May 4th and continued at this level until mid-June, then steadily declined. Numerically the scores were the highest the week of May 18th, at the peak of tree season; however, this was also when grass counts became significant (9 grains/m³). Symptom scores recorded during the week of May 4th (prior to the onset of grass season) and May 18th were not significantly different ($P = .189$). Symptom scores declined after June 8th following the peak of grass pollination ($P < .003$). *Alternaria* counts remained at low levels in early spring and began to rise in late May. Despite a continued increase of *Alternaria* counts, symptom scores steadily declined following the peak of grass pollination the week of June 8th. A lack of correlation between *Alternaria* counts

Table 3. Number, Percent, and Ratio of Patients Allergic to Tree or Grass Pollen by History and Skin Testing

No. of Patients with SAR*	Tree Allergic†	Grass Allergic‡	Ratio
189 (100%)	130 (69%)	134 (71%)	1:1

* SAR = seasonal allergic rhinitis.

† Tree allergic = presence of symptoms prior to May and has a positive skin test to at least one tree pollen.

‡ Grass allergic = presence of symptoms in May and June and has a positive skin test to at least one grass pollen.

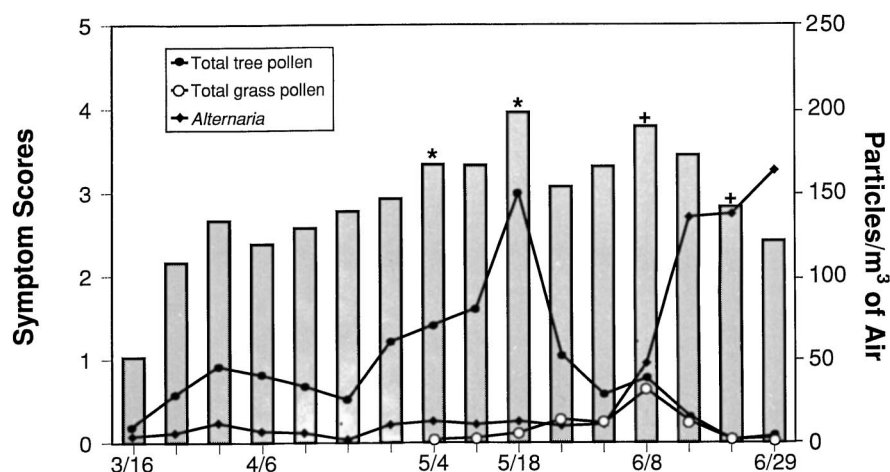


Figure 1. Symptom scores versus pollen and *Alternaria* counts. Weekly averages of daily symptom scores and counts are expressed. Date shown is the first day of the week. 0 = no symptoms; 1 = mild symptoms but not annoying; 2 = moderate symptoms and annoying; 3 = severe symptoms that interfere with daily activity or sleep. * $P = .189$ and + $P < .003$.

and symptom scores was apparent ($\mathcal{T} = 0.02$, $P = .65$) (Table 4).

Figure 2 represents the comparison of symptom scores and total and individual spore counts throughout the entire study period. No statistically significant correlations were detected for total spore counts, ascospores, *Cladosporium*, basidiospores, and *Alternaria*. The correlation coefficients and P values were 0.09, 0.25; 0.11, 0.20; 0.08, 0.30; 0.06, 0.35 and 0.02, 0.65, respectively (Table 4).

Twenty-four patients (47%) had positive skin tests to at least one of the fungal extracts. No significant correla-

tion was found in this subset of patients between their symptom scores and spore counts. The correlation coefficients and P values for the total spore counts, ascospores, *Cladosporium*, basidiospores, and *Alternaria* were 0.13, 0.17; 0.18, 0.10; 0.09, 0.25; 0.08, 0.28 and 0.01, 0.66, respectively (Table 4). It is noted that all of them had positive skin reactions to pollens (tree and/or grass).

The comparison of medication scores versus pollen and *Alternaria* counts is shown in Figure 3. Overall, the use of medication was low with a weekly average of less than two doses

a day. The pattern of medication scores was similar to that of symptom scores, with the exception that medication usage continued to increase following the peak of tree pollination the week of May 18th and reached a significantly higher level at the peak of grass pollination during the week of June 8th ($P < .02$). This was followed by a gradual decline ($P = .627$).

Table 5 summarizes the number and percent of patients allergic to tree or grass pollen in the prospective study. "Tree allergic" was defined as the development of symptoms during the period of tree pollination prior to the onset of grass season (prior to May 10th), with a positive skin test to at least one tree pollen tested. "Grass allergic" was defined as the presence of symptoms during grass pollinating period and a positive skin test to at least one grass pollen tested. Forty-three patients (84%) were allergic to tree pollen, and 39 patients (76%) were allergic to grass pollen. The difference between these percentages was not statistically significant ($P = .32$). The overlap was substantial with 31 patients (61%) being sensitive to both tree and grass pollens.

DISCUSSION

This study suggests that in Central Indiana, tree pollen is more important as a cause of seasonal allergic rhinitis than previously indicated in the litera-

Table 4. Correlation Between Symptom Scores and Pollen and Spore Counts

	Observation Periods*	Total Patients (N = 51)		Mold Positive Patients (N = 24)†	
		$\mathcal{T}‡$	$P§$	$\mathcal{T}$	P
Total tree pollens	3/16–5/18	0.73	0.002	—	—
Total grass pollens	5/25–6/29	0.79	0.018	—	—
Total spores	3/16–6/29	0.09	0.25	0.13	.17
Ascospores	3/16–6/29	0.11	0.20	0.18	.10
<i>Cladosporium</i>	3/16–6/29	0.08	0.30	0.09	.25
Basidiospores	3/16–6/29	0.06	0.35	0.08	.28
<i>Alternaria</i>	3/16–6/29	0.02	0.65	0.01	.66

* Periods when the respective pollens or spores are present. Date shown is the first day of the week.

† 24/51 (47%) patients had positive skin tests to fungal extracts.

‡ $\mathcal{T}$ = correlation coefficients.

§ $P \leq .05$ is considered to be significant.

|| Not done.

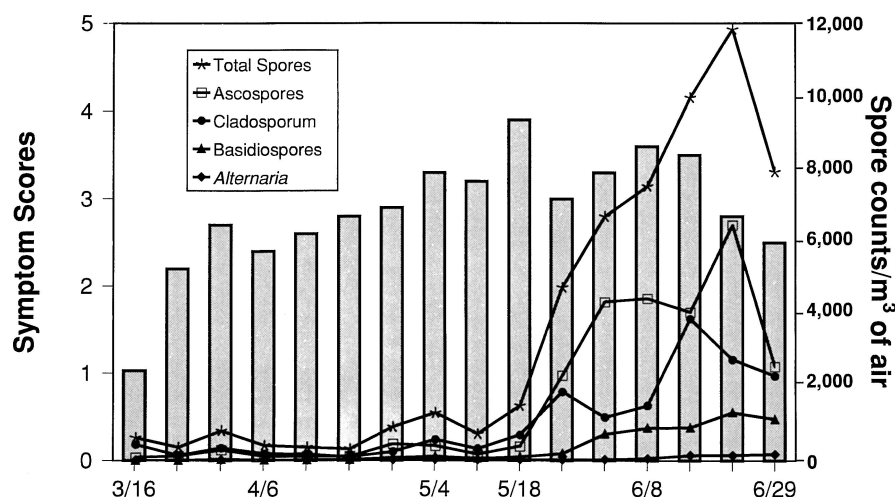


Figure 2. Symptom scores versus total and individual spore counts. Daily spore counts expressed as weekly averages began to rise in late May and stayed high in June. Yet, the symptom scores steadily declined following the week of 6/8. No correlation between the two variables was noted (Table 4).

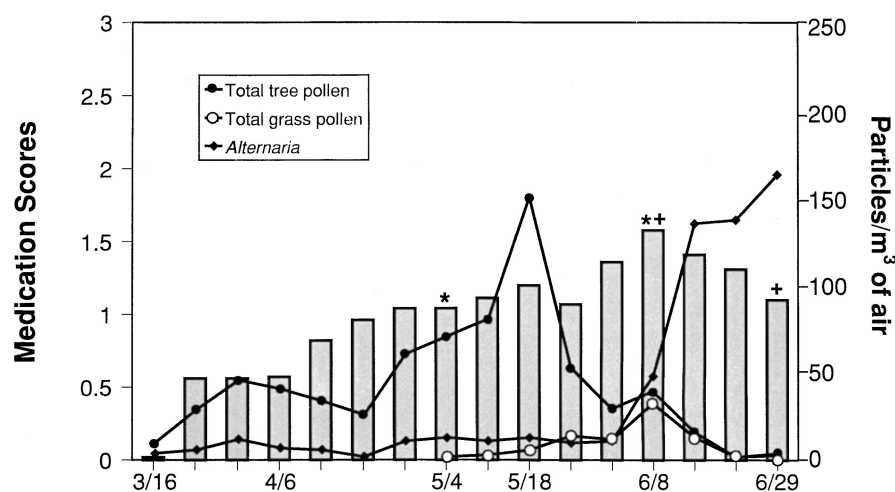


Figure 3. Medication scores versus pollen and *Alternaria* counts. Medication scores are the sum of daily medication usage with one point assigned to one dose of any medication used. A weekly average is expressed. Date shown is the first day of the week. * $P < .02$ and + $P = .627$.

ture.⁷⁻⁹ The importance of grass pollen is evident as shown by increased medication usage at the peak of grass pol-

lination in the prospective analysis (Fig 3). This study confirms the long held observation that seasonal allergic

rhinitis is primarily caused by airborne pollens; hence the term, pollinosis. Fungal spores, on the other hand, play a minor role in spring allergic rhinitis despite their presence at much higher concentrations than pollen grains and despite their ability to sensitize atopic individuals.^{5,12,20,21}

The literature citing the relatively low incidence of tree pollen-induced rhinitis compared with that of grass pollen appeared to derive from William B. Sherman's text book on allergy, published in 1968.²² In North America, an earlier study by Feinberg and Durham in Chicago²³ and a more recent study by Comtois and Gagnon in Montreal,²⁴ noted findings similar to those stated by Sherman. Studies in several Nordic countries yielded different results.^{25,26} The disparity among different investigations could be due to differences in geographic locations, methods of study, and perhaps, more importantly, the patient population. For example, our patients might not represent the general population, but rather, the type of patients typically seen by present day allergists in central Indiana. Most of our patients were referred by primary care physicians. They were highly atopic and had multiple sensitivities to various environmental allergens. Conversely, the group studied by Comtois and Gagnon represented patients who were not under the care of allergists.²⁴

The recruitment period for our prospective study took place in the early part of spring, coinciding with the tree-pollinating period. This could potentially bias the selection to include more patients with tree allergy. This possibility probably was not substantial, as the subjects were recruited prospec-

Table 5. Number and Percent of Patients Allergic to Tree or Grass Pollen in the Prospective Study

Subjects	Tree Allergic*	Grass Allergic†	P Value‡
51 (100%)	43 (84%)	39 (76%)	.32

* Tree allergic = presence of symptoms during tree pollinating period prior to the onset of grass season and has a positive skin test to at least one tree pollen.

† Grass allergic = presence of symptoms during grass season and has a positive skin test to at least one grass pollen.

‡ Not statistically significant between the two groups.

tively from our patient databases which had been accumulated over many years and was not based on the presence of symptoms during the recruitment period. Patients who had tree or grass sensitivities would have had an equal opportunity to respond to our recruitment efforts.

As with many previous studies that attempted to correlate clinical symptoms and pollen counts,^{24,26-28} we found a significant degree of correlation between weekly average symptom scores and weekly average pollen counts. Such a correlation, however, was difficult to discern when comparing individual daily symptoms with daily pollen and spore counts. The difficulties we encountered were not unlike those discussed by many authors.^{3,29-32}

Fungi have been known to cause allergic rhinitis for more than 60 years and fungal extracts have been used extensively for the diagnosis and treatment of respiratory allergic diseases despite many unresolved problems.^{12,33} There has been a paucity of direct comparison between fungal spores and pollens as the cause of allergic rhinitis. The mucous membranes of the nose and eyes of allergic individuals are regularly exposed to fungal spores far in excess of pollen grains at a given time.¹² An important factor to account for the relative lack of allergenicity of fungal spores as demonstrated in the present study probably is due to the fundamental structural difference between spores and pollens.³⁴ Fungal spores contain a rigid outer cell wall which prevents the rapid release of potentially allergenic proteins upon contact with nose and eye mucous membranes. In contrast, pollen grains have pores or furrows which allow rapid release of allergenic proteins once contact with the mucous membranes occurs. Furthermore, some fungal allergens are not present in the resting spore state, but only after germination on the host tissues.³⁵

In conclusion, we found a high incidence of tree pollen-induced allergic rhinitis in Central Indiana in a patient population seen by practicing aller-

gists. Both tree and grass pollens were much more important than fungal spores as causative allergens. Since outdoor airborne allergens vary in different geographic locations, similar studies carried out in different regions would assist practicing physicians in more precise etiologic diagnosis and therefore, better treatment of this common problem.

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