

Sensitization to aeroallergens among patients with allergic rhinitis in a desert environment

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Background: The causative allergens of allergic rhinitis in desert environments are uncertain.

Objective: To determine the sensitizing aeroallergens in patients with allergic rhinitis in Kuwait, a desert country.

Methods: A total of 706 patients aged 6 to 64 years (mean 34.3 years) with allergic rhinitis were studied. Sera from the patients were screened for specific IgE to 14 inhalant allergens by the CAP-RAST method.

Results: Specific IgE to any allergen was detected in 86.3% of patients. The prevalence rates for allergen groups were: pollens (77.3%), house dust (62.3%), and molds (14.7%). The individual allergens with the highest positive rates were pollens of the weed *Chenopodium* (64.3%); Bermuda grass (55.0%), and *Prosopis* tree (50.3%). These plants were all imported and cultivated for the purpose of "greening" the desert. German cockroach (48.2%) and house dust mites (32.4% to 39.2%) were the most prevalent indoor sensitizers. With the exception of the molds, sensitization rates were higher for males than females. The youngest age group (6 to 17 years) had significantly higher sensitization rates than the older ones, particularly with respect to the molds ($P < .01$ to $.001$). Severe sensitization was more common with *Alternaria* than the other allergens and in general mold sensitization was more frequently associated with severe symptoms. Polysensitization was very common, with 81.8% of all sensitized patients positive to more than one allergen.

Conclusions: Pollens of the local horticultural plants are the main sensitizing allergens among patients with allergic rhinitis in this desert environment. The practices that "green" the desert seem to also encourage allergen sensitization.

Ann Allergy Asthma Immunol 2000;84:433–438.

INTRODUCTION

In the last two decades, the prevalence of allergic diseases in various parts of the world has been on the increase.^{1–4} In Kuwait, a small desert country northeast of the Arabian Peninsula, allergic diseases are common,^{5–7} with allergic rhinitis being highly prevalent.

This might appear surprising because the climate is dry and very hot in summer and there is little or no vegetation in most parts of the country—conditions considered as unfavorable for the availability of aeroallergens such as house dust mite and pollens.^{8,9}

The identification of the causative allergens in this environment has received very little attention. The allergens prevalent in the West are considered unlikely to be important here and vice versa. In fact, among asthmatics in Kuwait, skin reactions to pollens of the local ornamental plant, mesquite (*Prosopis juliflora*), were found to be by far more frequent than those of house dust mites (*Dermatophagoides pteronyssinus* and *Dermatophagoides farinae*),⁶ which are more common in Europe and North America.^{10,11}

Sensitizing allergens can be detected either by the skin prick test (SPT) or the radioallergosorbent test (RAST). Skin tests are valuable because of their simplicity, low cost and good sensitivity, but they may be affected by variability in the skin responsiveness to mediators, hormonal status, and allergen potency.¹² They are also time-consuming, especially when a large number of patients and allergens are being investigated. The radioallergosorbent test on the other hand is essentially unaffected by these factors and has the additional advantage of being exquisitely quantitative and precise. Being an in vitro test, it lacks the more useful tissue response aspect of SPT. It is also expensive.

In the current study, we have employed the Pharmacia CAP-RAST test—a fluorimetric modification of the conventional RAST—to investigate the presence of allergen-specific IgE antibodies and the characteristics of sensitization in Kuwaiti patients with allergic rhinitis.

MATERIALS AND METHODS

Patients

The study involved a total of 706 patients [male:female ratio of 1.4 and mean age of 34.3 years (range 6 to 64 years)] with allergic rhinitis (seasonal or perennial). They were recruited randomly from among patients attending the Kuwait Allergy Centre between Jan 1997 and December 1998. Recruitment was stratified in order to cover two whole seasons and to avoid seasonal bias. Informed consent was obtained from all patients (parents of children) before participation. The study was approved by the Faculty of Medicine Ethical Committee.

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This work was supported by grant #95-07-06 from The Kuwait Foundation for the Advancement of Sciences (KFAS).

Received for publication July 10, 1999.

Accepted for publication in revised form October 16, 1999.

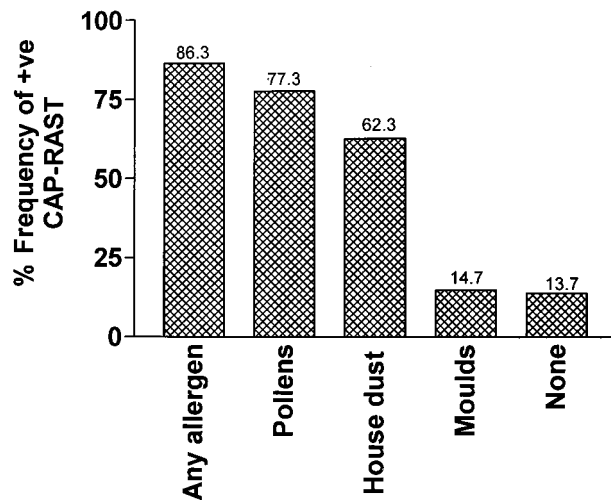


Figure 1. Frequency of IgE sensitization to aeroallergens among patients with allergic rhinitis. N = 706.

The diagnosis of allergic rhinitis was established by a combination of clinical history, physical examination, and a positive SPT reaction (diameter ≥ 3 mm) to at least one of five aeroallergens: grass pollen mix, tree pollen mix, date palm pollen, house dust, and *Aspergillus fumigatus*. A study questionnaire requesting demographic data, family history of atopy, smoking habit,

and respiratory symptoms was also administered to each patient.

Asthma was considered to be present in persons with a history of episodic shortness of breathe, wheezing, and difficulty in expiration. Allergic rhinitis occurred alone in 409 (57.9%) and co-existed with asthma in the rest. Two hundred and four patients (28.9%) had clear family history of

atopy while 475 (67.3%) claimed they did not. The rest were equivocal or did not know. Rhinitis was classified as either mild/moderate or severe according to the frequency and intensity of clinical symptoms, sinus involvement, and nasal steroid requirement. Consequently, 64 out of the 706 patients (9.1%) were classified as having severe rhinitis. Only 80 patients (11.3%) were active smokers.

Venous blood samples were taken once from each patient, and the separated serum stored at -43°C for less than 3 months before analysis.

IgE Antibody Measurement

The Pharmacia CAP-FEIA test system, comprising the CAP-RAST and CAP-IgE tests were employed to measure the allergen-specific IgE and total serum IgE, respectively. The assays were calibrated against the WHO reference serum 75/502. The working ranges of the assays were 0.35 to 100 kU/L for CAP-RAST and 2 to 2000 kU/L for CAP-IgE. Specific IgE values greater than 0.35 kU/L (or CAP-RAST class ≥ 1) were regarded as positive.

All samples were screened for IgE antibodies to the following 14 allergens: house dust mites (*D. pteronyssinus*, *D. farinae*, and *D. microceras*); pollens of Bermuda grass (*Cynodon dactylon*), Mesquite (*Prosopis juliflora*), Date palm (*Phoenix canariensis*), Eucalyptus tree (*Eucalyptus species*), Cajput tree (*Melaleuca leucadendron*) and Goosefoot (*Chenopodium album*); cat dander; cockroach (*Blattella germanica*), and molds (*Aspergillus fumigatus*, *Cladosporium herbarum* and *Alternaria alternata*). These were thought to be relevant to this environment either by aerobiologic criteria or local SPT experience.

Analysis of Data

All data were analyzed on SPSS statistical program (SPSS Inc, Chicago USA) on a personal computer. For statistical purposes, total IgE values less than 2 kU/L were assigned a value of 1 kU/L. The severity of sensitization to individual allergens was expressed in CAP-RAST classes of 0 to 6. Groups

Table 1. Frequency of Specific IgE to the Individual Allergens Among Patients with Allergic Rhinitis

Allergen	Number of Subjects with Positive Tests	% Frequency	
		All Patients (N = 706)	All Positive Cases (N = 609)
Indoor allergens			
Cockroach	341	48.3	56.0
Mite (<i>D. microceras</i>)	277	39.2	45.5
Mite (<i>D. pteronyssinus</i>)	257	36.4	42.2
Mite (<i>D. farinae</i>)	229	32.4	37.6
Cat dander	155	22.0	25.5
Outdoor allergens (pollens)			
Chenopodium	454	64.3	74.5
Bermuda grass	388	55.0	63.7
Prosopis	355	50.3	58.3
Cajput tree	306	43.3	50.2
Eucalyptus	273	38.7	44.8
Date palm	260	36.8	42.7
Outdoor/indoor allergens (molds)			
<i>Aspergillus</i>	65	9.2	10.7
<i>Alternaria</i>	40	5.7	6.6
<i>Cladosporium</i>	32	4.5	5.2
Any of cockroach, <i>Chenopodium</i> , Bermuda grass or Prosopis	562	79.6	92.3

were compared by analysis of variance and differences tested by chi-square test (categorical responses) and independent t-test (group means). Significance was set at $P < .05$.

RESULTS

The frequency of positive specific IgE to at least one allergen was 86.3% (Fig 1). The values for the allergen groups were 77.3% for pollens, 62.3% for house dust allergens (house dust mites, cockroach and cat dander), and 14.7% for the molds. Ninety-seven patients (13.7%) were negative to all 14 allergens. The frequency of positivity for the individual allergens is shown in Table 1. The highest rate was 64.3% for the weed *Chenopodium*, followed by Bermuda grass (55.0%), *Prosopis* tree (50.3%), and cockroach (48.2%). The frequency of positivity to any of these four allergens was 79.6% (or 92.3% of all positive cases). The lowest rates were obtained for the molds: 4.5% for *Cladosporium*, 5.7% for *Alternaria*, and 9.2% for *Aspergillus*. The house dust mites had intermediate rates: 36.4%, 32.4%, and 39.2%, respectively, for the three species *D. pteronyssinus*, *D. farinae*, and *D. microceras*. The rate for Date palm, the only plant native to the Arabian Desert, was 36.5%. Other allergens with intermediate rates were the Cajput tree (43.3%), Eucalyptus tree (38.7%), and cat dander (22.0%).

For all allergens, the frequency of sensitization was higher for males than females (Table 2). The differences were statistically significant, especially for the pollens and cockroach ($P < .01$ to $.001$), but not for the molds and cat dander. For the mites (except *D. pteronyssinus*), the rates were also significantly higher for males, although the difference was relatively weak ($P < .05$). A strong influence of sex was also seen with the total serum IgE, for which the geometric mean value was significantly higher in males (428.4 kU/L) than females (216.3 kU/L), $P < .001$.

As shown in Table 3, the analysis of the sensitization rate according to age groups revealed a striking preponder-

Table 2. Influence of Sex on the Frequency of IgE Sensitization to Airborne Allergens and to Total IgE Among Allergic Rhinitis Patients

Allergens	% Frequency of Sensitization		
	Males (N = 417)	Females (N = 289)	Significance Level (P Value)
Mite (<i>D. pteronyssinus</i>)	38.4	31.8	NS
Mite (<i>D. farinae</i>)	36.9	23.5	<.05
Mite (<i>D. microceras</i>)	44.4	29.4	<.05
Cat dander	23.5	18.3	NS
Cockroach	55.4	33.9	<.001
Bermuda grass	61.4	44.3	<.001
Date palm	42.9	24.6	<.01
Eucalyptus	46.3	22.8	<.001
<i>Prosopis</i>	57.1	38.8	<.001
Cajut tree	51.1	29.8	<.001
<i>Chenopodium</i>	70.5	53.6	<.001
<i>Cladosporium</i>	5.3	3.5	NS
<i>Aspergillus</i>	10.3	6.6	NS
<i>Alternaria</i>	6.2	4.5	NS
Any allergen	89.0	79.2	
Total IgE [geometric mean, (kU/L)]	428.4	216.3	<.001

NS = not significant.

* By χ^2 test.

ance of mold sensitization among children (6 to 17 years) compared with adults. The rates for the three molds ranged from 20.0% to 32.7% for the age group 6 to 17 years, compared with values of 2.5% to 9.4% for any of the older age groups, $P < .001$ in all cases. For most of the pollens, the values for the 6 to 17 years age group were also significantly higher, although less dramatic, when compared with the 45+ years age group, $P < .05$ for each. For all 14 allergens, however, there were no significant differences in the sensitization rates among the 3 adult age groups. The geometric mean of total IgE was significantly lower in the 45+ years age group (225.2 kU/L) compared with any of the younger age groups (315.2 to 362.5 kU/L), $P < .5$ to $.01$.

For most allergens, the rate of sensitization was not different in the group with rhinitis alone compared with the group with both rhinitis and asthma (data not shown). The only exceptions were the 2 molds *Cladosporium* and *Aspergillus*, as well as cat dander, all of which had sensitization rates significantly higher in the group with asthma.

Among sensitized patients, polysensitization was particularly common. As shown in Table 4, as much as 81.8% of all sensitized patients was positive for more than one allergen, with about 45% being sensitized to 6 or more allergens. Both the extent of polysensitization and the mean number of allergens per patient were significantly higher in males than females, $P < .05$ to $.001$.

The analysis of the severity of sensitization by the individual allergens (estimated as the % frequency of CAP-RAST class ≥ 4) and its relationship to the severity of symptoms (% frequency of severe cases) is shown in Figure 2. The frequency of severe rhinitis was significantly higher in patients sensitized to any of the three molds (13.8%, 16.4% and 17.1%, respectively for *Cladosporium*, *Aspergillus*, and *Alternaria*) compared with the other allergens ($\leq 8.5\%$) $P < .01$. On the other hand, severe sensitization occurred by far more frequently with *Alternaria* (37.1%) and Bermuda grass (22.2%) than the other allergens ($\geq 10.2\%$). Although both severe sensitization and severe symptoms uniquely occurred more frequently with *Alternaria*, there

Table 3. Influence of Age on the Frequency of IgE Sensitization to Airborne Allergens and to Total IgE Among Allergic Rhinitis Patients

Allergens	% Frequency of Sensitization			
	6–17 yr (N = 52)	18–30 yr (N = 203)	31–45 yr (N = 346)	45+ yr (N = 105)
Mite (<i>D. pteronyssinus</i>)	32.7	43.8	33.6	32.4
Mite (<i>D. farinae</i>)	31.0	43.3	41.2	25.0
Mite (<i>D. microceras</i>)	36.0	43.8	40.8	32.7
Cat dander	41.3*†	22.9	19.7	18.4
Cockroach	42.3	51.2	50.3	40.4
Bermuda grass	55.8*†	54.5	58.6	44.8
Date palm	26.1*‡	22.1	44.9	32.8
Eucalyptus	49.0*†	31.7	43.0	30.8
<i>Prosopis</i>	61.5*†	45.5	54.8	40.0
Cajut tree	41.2	32.3	51.7	38.1
<i>Chenopodium</i>	73.1*†	63.2	67.2	53.3
<i>Cladosporium</i>	26.0§¶	2.7	2.5	3.9
<i>Aspergillus</i>	32.7§¶	9.4	5.9	7.8
<i>Alternaria</i>	28.6§¶	6.0	2.8	2.9
Total IgE [GM, (kU/L)]	315.2*†	362.5§†	360.5§†	225.2

GM = geometric mean.

* $P < .05$.

† Compared with any other age group.

‡ Compared with 31 to 45 year age group.

§ $P < .001$.

¶ Compared with any other age group.

§ $P < .01$.

Table 4. Polysensitization Among Sensitized Allergic Rhinitis Patients According to Sex

Number of Positive Allergens	% Frequency		
	All Patients (N = 609)	Males (N = 375)	Females (N = 234)
1 only	18.2	15.7	23.5
2–5	36.3	30.1	48.3
6–10	38.6	45.9*	24.8
11–14	6.9	8.5†	3.8
Total polysensitized	81.8	84.3†	76.5
Extensive polysensitization (≥6 allergens)	45.5	54.2*	28.5
Mean ± SD allergens/patient	5.2 ± 3.1	6.6 ± 3.4*	4.1 ± 3.5

* $P < .001$.† $P < .05$.‡ $P < .01$.

was no overall correlation of the intensity of sensitization with symptom severity as determined by multiple regression analysis for each allergen or among allergens (data not shown).

DISCUSSION

This study has shown that even with the scant vegetation of desert environments, pollens still constitute the major sensitizing allergens in patients with allergic rhinitis, with as much as

77.3% of all patients (or 89.5% of all positive cases) sensitized to at least one pollen. The three most prevalent sensitizing pollens were those of *Chenopodium* (a weed), Bermuda grass, and *Prosopis* (a tree). These plants are common in the inhabited part of the country but were all imported and planted either as shade or ornamental plant or for binding sand. Together with cockroach, they constitute the four most prevalent sensitizers. The

prevalence of at least one of these four allergens was around 80%, thus suggesting that the four allergens alone might be adequate to detect around 80% of all atopic cases in this locality. The Date palm—the only plant native to the Arabian Desert—had intermediate prevalence (36.8%), even though its local abundance is comparable. Whether this reflects a lower allergenicity of date palm pollen is uncertain, but it is known that the pollen grains are relatively heavy and therefore less likely to be suspended in air.¹³ Similar sensitization pattern was seen in a previous study of the normal population in this country.¹⁴

In most European and North American countries, the allergens with the highest sensitization rates among patients with nasal symptoms, whether by SPT or RAST, are the pollens of the birch, timothy and ragweed plants; house dust mites and cat dander. The rank order depending on the location.^{10,11,15} In contrast, house dust mite were reported to have the highest rate of sensitization among patients with allergic rhinitis in Thailand¹⁶ and Mex-

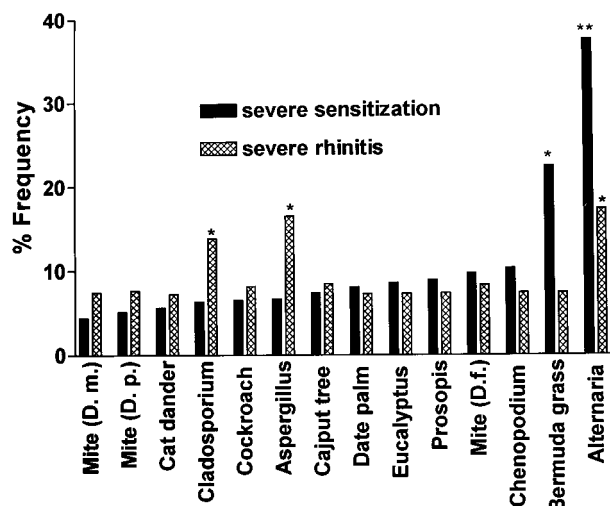


Figure 2. Frequency of severe sensitization and severe rhinitis among patients sensitized to the individual allergens. The number (N) of positive cases for the individual allergens ranges from 68 to 341. * $P < .01$; ** $P < .001$.

ico.¹⁷ In one study conducted in a desert environment in Tucson, Arizona, Halonen and co-workers¹⁸ reported a prevalence pattern that is somewhat different from ours. For example, among the 11 year olds with rhinitis, the prevalence rates of SPT positivity of 51.0%, 34.3%, 27.3% and 15.6%, respectively, were reported for Bermuda grass, Mesquite, *Alternaria*, and *D. farinae*. The corresponding values in our study (6 to 17 years age group) were 55.8%, 61.5%, 28.6%, and 31.0%. This suggests that in addition to the climate, other local factors probably contribute to the pattern and intensity of allergen sensitization.

The finding that cockroach is the most prevalent indoor sensitizing allergen, with nearly half of all patients sensitized, is interesting but not surprising, since cockroaches are known to be ubiquitous and highly allergenic.¹⁹ On the other hand, the sensitization rate of up to 39% for the mites was unexpected. Mites tend to require a minimum relative humidity of 60% and moderate temperatures (around 25°C) to thrive,^{8,9} whereas in Kuwait, the mean relative humidity is less than 15 and the average summer temperatures exceed 42°C. In fact, early SPT results among Kuwaiti asthmatics showed very low (<10%) frequency of

positivity for mites.⁶ It is likely that the extensive use of air conditioners in Kuwait in recent times may well have created the indoor climatic condition conducive to mite growth.

We observed that as much as 13.7% of our patients were negative for all the 14 allergens, even though they were selected on the basis of having at least one positive SPT result. Although a similar observation has previously been made,²⁰ it is uncertain if this reflects a higher sensitivity of SPT or its liability for false positive results.

Of all the factors examined, sex had the most significant effect on the frequency of sensitization. With the exception of the molds, males generally had higher values than females and this may be the basis for the higher prevalence of allergic diseases in males compared with females in this community.^{7,14} Similar findings have been reported for other countries.^{21,22} No convincing explanations have been given for these sex differences. There is no evidence to suggest that differential exposure to the allergens may occur between the sexes. It is also unlikely to relate to the higher rate of smoking among males, since in our study, only 11.3% of the patients were active smokers. Furthermore, this effect of sex still remained even when smokers

were excluded from analysis (data not shown). It may rather be a reflection of the generally higher total IgE values as seen in this and other studies.^{23,24}

For the non-mold allergens, the influence of age was relatively mild, with the youngest age group (6 to 17 years) having prevalence rates that were significantly higher than only the oldest (45+ years) age group, $P < .05$. Age-dependent decrease in allergen-specific IgE has been reported by many workers,^{18,22,23} but not others.^{24,25} The most dramatic effect of age was seen with the molds for which the sensitization rate dropped from around 30% in the 6 to 17 years age group to less than 10% in the older age groups. This shows that in this community, mold allergy is essentially a childhood problem. How children outgrow mold allergy is uncertain but merits adequate study.

In terms of the severity of symptoms, molds appear to be unique. Although they had a relatively low sensitization rate, they tended to be associated with more severe rhinitis. This may be explained by the fact that sensitization to molds occurs more frequently in patients who also have asthma,²⁶ and therefore may have had their symptoms complicated by asthma. Of interest, though, is the finding that the ability to cause severe sensitization is not synonymous with the ability to produce severe disease as seen, for example, with Bermuda grass.

In summary, these results have shown that the pollens of ornamental plants, cockroaches and the house dust mites can be major sensitizing allergens in a desert environment. They also highlight the difficult social and public health implications since the practices that make the desert habitable (horticulture and air-conditioning) appear to be the ones encouraging allergen sensitization, and ultimately allergic disease. It is, therefore, suggested that non-flowering plants or plants with low allergenic pollens be considered as alternatives in the planning of the "greening" programs of desert countries.

ACKNOWLEDGEMENT

We are grateful to the Ministry of Public Health, Kuwait, for the permission to source our patients from Government Health institutions and to Mrs Elizabeth Philips for her technical assistance.

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