

Sensitization to house dust mites in different climatic areas

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With the use of local meteorologic data, the mean monthly indoor relative humidity (RH) was calculated for the area of residence of each of 774 children with respiratory symptoms who were referred to our allergy clinic. Seven hundred fourteen children lived in areas in which the mean indoor RH was 50% or more for 4 or more mo per year ('humid' areas), and 60 children lived where this RH was present for no more than 2 mo per year ('dry' areas). Of those children from the 'humid' areas, the skin prick test was positive to Dermatophagoides farinae in 31% and D. pteronyssinus in 40%, whereas in those children from 'dry' areas, tests were positive in 3% and 2%, respectively, ($p < 0.001$). There was also a marked difference in the degree of sensitivity. In those children with a positive RAST (more than 12% of binding relative to allergen-specific pooled reference sera), the mean level of binding was $51\% \pm 3.5\%$ for D. farinae and $62\% \pm 4.4\%$ for D. pteronyssinus in children from 'humid' areas but never exceeded 14% for either species in those children from 'dry' areas ($p < 0.001$). Sensitivity to D. farinae and D. pteronyssinus is frequent in 'humid' areas and seldom, if it is ever, occurs in areas that are 'dry,' either as a result of a semiarid climate or a prolonged heating season. These findings have implications for the etiologic diagnosis and specific treatment of atopic patients living in different climatic regions. (J ALLERGY CLIN IMMUNOL 76:108-12, 1985.)

There are several reasons for needing to know whether mite allergy is responsible for a patient's respiratory symptoms. The two main reasons for establishing this etiologic diagnosis relate to specific treatment. First, appropriate mite-avoidance measures in the bedroom decreases symptoms in mite-sensitive asthmatic patients,¹ and, second, mite immunotherapy appears to be helpful in some of these patients.²⁻⁴

House dust mites are numerous,⁵ and mite sensitivity is known to be frequent in England and in other places with a mild humid climate,⁶⁻⁸ but there is little information about the prevalence of mite sensitivity in areas that are semiarid or have a prolonged heating season. We predict that mite sensitivity is infrequent in these areas, especially where the mean monthly indoor RH is less than 50% for all but 2 mo of the year. Our reasons for advancing this hypothesis are

Abbreviation used

RH: Relative humidity

as follows: both *D. farinae* and *D. pteronyssinus* mites become dehydrated and die when they are kept at a RH less than 50% under controlled laboratory conditions,^{9, 10} mites are sparse in houses in dry areas such as the California desert¹¹ and the interior regions of South Africa,¹² and in humid areas, such as Vancouver,¹³ mite numbers decrease markedly during the months when central heating keeps the indoor RH below 50%.¹⁴⁻¹⁸ Even when the optimum RH for a species is reached, the mite population does not expand immediately. A month or 2 elapses before numbers increase.^{14, 19}

Our allergy clinic is favorably situated to test this hypothesis. Children are referred to the clinic from cities throughout British Columbia, a province covering an area of 366,255 square miles and with diverse climatic areas. These include a mild humid coastal belt, a humid continental zone with warm summers, a humid continental zone with cool summers, and a semiarid continental region.²⁰

In this article we report a study of mite sensitivity in children who reside in these areas and who have symptoms of respiratory allergy.

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METHODS

Subjects

The study population comprised 774 children who had always lived in British Columbia and who were referred consecutively to our clinic for evaluation of their symptoms of respiratory allergy. They were observed between March 1982 and July 1983. Accompanying parents were asked standardized questions by a trained interviewer. Besides questions about symptoms,²¹ the parents were asked where the child's home was at the time and whether he had previously resided elsewhere in the province.

A subgroup of 116 subjects, observed consecutively during the heating season when recall would be accurate, was asked the temperature at which they kept their houses. There was little variation, the mean temperature being 18.836° C with a standard error of 0.177° C. Also, the subgroup was comparable to the total group in male to female ratio and symptoms of allergy and sensitivity to mites. Although the mean age of the subgroup was 6 yr and that of the total group was 7 yr, there was no association between age and the temperature to which the house was heated. The mean house temperature in the subgroup was deemed representative of the total group.

Skin prick tests and RAST

After all history taking and examination had been completed, a technologist performed skin prick testing in a standard manner²² by use of the following glycerinated extracts: 1% *D. farinae* and 1% *D. pteronyssinus* (Bencard, Beecham Laboratories, U. K.), 2% acetone-precipitated cat and dog hair (Hollister-Stier, Spokane, Wash.), and local tree, grass, and weed pollens, 1000 Noon units per milliliter (Greer Laboratories, Lenoir, N.C.). A negative control test was performed with 50% glycerine in carbol saline, and a positive control test was performed with 0.1% histamine phosphate. The mean diameters of the resulting wheals were measured 20 min later by an independent physician-observer. A reaction was positive if the wheal diameter was 2 mm larger than the wheal diameter in the negative control test.

Venous blood was drawn for RAST in all who had a history suggestive of mite or house dust allergy,²¹ but a negative prick test to mites, and also in a random sample of other subjects. Serum samples were analyzed without knowledge of the origin of the patient by use of the standard Pharmacia (Uppsala, Sweden) methodology with the following modifications: Mite allergen-conjugated cellulose discs (cyanogen bromide method) were prepared from the same extracts that were used for skin tests. Twenty microliters of serum was added to each of duplicate tubes containing the discs, diluted with 150 µl of buffer and incubated for 3 hr at room temperature. After washing, 50 µl of ¹²⁵I-labeled anti-IgE (Pharmacia) was added, and the tubes were incubated at room temperature for 18 hr. After further washes, the remaining bound radioactivity was quantitated in a gamma spectrometer. For each run an allergen-specific (*D. farinae* or *D. pteronyssinus*) pooled reference serum was run in parallel with dilutions of 0, 1/4, 1/24, 1/48, and 1/96, and a standard curve was drawn. Binding

of radioactivity by test sera of more than 12% of the maximum binding of reference serum (mean + 2 SD of background radioactivity) was considered as a positive test. The specificity of the assay for mite allergen was demonstrated by inhibition of binding of reference serum when the serum was preincubated with dialyzed mite-allergen extract.

Initially, only *D. farinae* extract was used for skin testing and RAST, as it is said to cross-react with *D. pteronyssinus*.²³ However, in the case cross-reactivity was not complete and as the two mite species are found in British Columbia,¹⁶ extracts of both species were used in the remaining 627 subjects. Altogether, RAST was performed for *D. farinae* in 311 and for *D. pteronyssinus* in 234 subjects.

Relative humidity

The mean monthly indoor RH for each area of residence of the patients was estimated in the following way: Data for mean monthly outdoor RH and temperature were obtained from 41 meteorologic stations located in different parts of the province.¹³ By use of the Smithsonian tables,²⁴ the mean weight of water per cubic meter of air was calculated for each month of the year at each of the 41 stations. These weights were each expressed as a percentage of 15.9 gm, the weight of water in a saturated cubic meter of air at 18.8° C. This temperature was the mean of the temperatures at which the subjects kept their houses. In Victoria, for example, the mean outdoor dry bulb temperature in January is 4.4° C. According to the Smithsonian table, a cubic meter of saturated air at 4.4° C holds 6.4 gm of water. However, the mean outdoor RH in January is only 86% so that the actual weight of water in the air is

$$\frac{6.4 \times 86}{100} = 5.5 \text{ gm/m}^3$$

Meanwhile, the house temperature is 18.8° C. The weight of water in 1 m³ of saturated air at this temperature is 15.9 gm. Therefore, the mean indoor RH is

$$\frac{5.5 \times 100}{15.9} = 34.6\%$$

No adjustment was made in RH when the mean temperature for the month was more than 18.8° C because under these conditions, outdoor and indoor RH are the same.²⁵ Air conditioners, which lower RH, are uncommon in British Columbia as uncomfortably hot and humid weather is unusual. The highest mean monthly temperature in Vancouver, for example, is 17.2° C. In parts of the province in which the mean temperature may reach 21° C, the RH is sufficiently low for the heat to be quite bearable.

When the areas of the province are graded according to the number of months during which the mean indoor RH is 50% or more, the areas fall into two distinct groups. In one group this level of indoor humidity is present for 4 or 5 mo per year. For the sake of brevity these areas, and the houses in them, will be referred to as "humid" hereafter. This group includes greater Vancouver and the other "humid" areas on the coast and in the interior, the source of 91% of the subjects. In the second group of areas, the mean indoor RH is 50% or higher for no more than 2 mo per year, either because of a semiarid climate or as the result

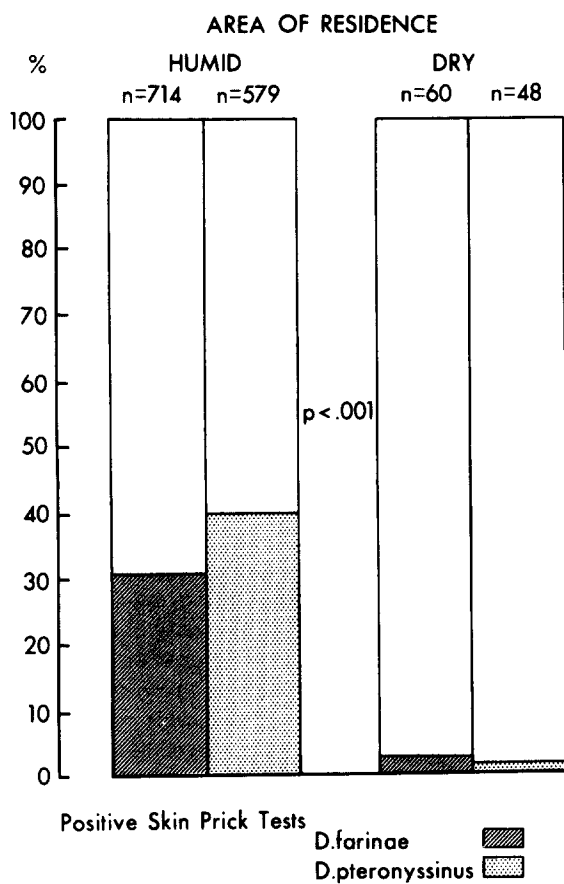


FIG. 1. The frequency of positive skin prick tests to *D. farinae* and *D. pteronyssinus* in two groups of children with allergic respiratory symptoms, the area of residence of the one group being "humid" and the other "dry."

of a prolonged heating season with a short, cool summer. These areas, and the houses in them, will be referred to as "dry." Eight percent of the subjects had always lived in such an area. One percent, although currently residing in a "dry" area, had previously lived in a "humid" region. Since they could have become sensitized to mites in the "humid" area, they are, for purposes of analysis, included with the group from the "humid" areas. There is no area in the province in which a mean RH of 50% is present for only 3 mo.

Statistical analysis

All tests performed were two-tailed tests of differences between means or proportions depending on whether the variable was a continuous variable, such as age, or a proportion, such as percent sensitive. Tests were deemed significant when p was <0.05 and highly significant when p was <0.01 . Mean data are expressed as mean $\pm$ SEM.

RESULTS

The frequency of positive skin prick tests to *D. farinae* was 31% and 40% to *D. pteronyssinus* among children from the "humid" regions, whereas among those from the "dry" regions, only 3% had a positive

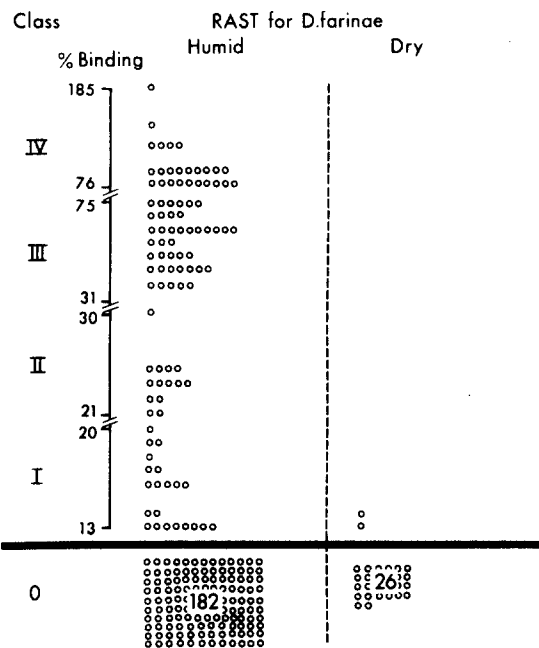


FIG. 2. The level of serum binding to *D. farinae*, expressed as a percentage of the binding in antigen-specific pooled reference sera, in two groups of children with allergic respiratory symptoms, the area of residence of the one group being "humid" and the other "dry."

response to either of the mites (Fig. 1). The frequencies of positive skin prick tests in those from humid and dry areas were significantly different from one another ($p < 0.001$), and the 95% confidence interval for the proportion of tests from the dry area included 0%, implying that a child who has always lived in a dry area has a very small chance, or no chance at all, of being sensitive to mites.

Not only were those children from "humid" areas more often sensitive to mites than those from "dry" areas but also the sensitivity, when it occurred, was much greater, judging by the percent binding of the RAST for both *D. farinae* and *D. pteronyssinus*. In subjects from the "humid" areas who had a degree of binding for *D. farinae* that exceeded the background radiation level, the mean binding was $51\% \pm 3.5\%$ of the reference serum (Fig. 2). In subjects from the "dry" area, by contrast, only two had a binding that was higher than the background radiation level of 12%. It was 13% in one subject, and 14% in the other subject. The results were similar for *D. pteronyssinus*. In those subjects with a RAST binding exceeding the background radiation level, the mean for those subjects from the "humid" area was $62\% \pm 4.4\%$, whereas in the single positive case from the "dry" area, the level was 13%. Altogether, RAST was performed on 40% of subjects from "humid" areas and on 47% of subjects from "dry" areas.

There was incomplete cross-reactivity between *D.*

TABLE I

	"Humid" area	"Dry" area	p Value	Significant
Age in years*	7.51	7.02	0.331	NS
Proportion M:F	424:256	34:26	0.252	NS
Mean house temp (°C)†	18.77	19.25	0.361	NS
Ownership of dog (%)*	30.4	36.7	0.383	NS
Positive prick test to dog (%)*	19.7	29.3	0.098	NS
Ownership of cat (%)*	24.7	23.7	0.933	NS
Positive prick test to cat (%)*	29.5	33.3	0.650	NS
Positive prick test to pollen (%)*	43.6	36.4	0.451	NS

The comparability of a number of variables in two groups of children with allergic respiratory symptoms, the area of residence of the one group being "humid" and the other "dry." NS = not significant.

*774 subjects total.

†116 subjects total.

farinae and *D. pteronyssinus*. Of 633 subjects who had a skin prick test for the two species, 26% had a positive reaction to both, 4% reacted only to *D. farinae*, and 11% reacted only to *D. pteronyssinus*. Similarly, RAST was performed with the two allergens in 236 subjects with a positive result to both in 26% but with a positive result only to *D. farinae* in 5% and only to *D. pteronyssinus* in 3%.

There was no significant difference between the two groups in age or in the male to female ratio (Table I). The two groups were also comparable for atopy, judged by sensitivity to inhalant allergens to which they were equally exposed. Similar proportions in "humid" and "dry" areas owned cats and dogs, and comparable proportions had positive prick tests to these animals. Exposure to pollen is less uniform, the types of pollen and length of the pollinating season varying considerably between "humid" and "dry" areas. Nonetheless, there was no significant difference between the two groups in the percentage that was sensitive to one or more tree, grass, or weed pollens.

DISCUSSION

The finding that sensitivity to *D. farinae* and *D. pteronyssinus* in atopic children occurs frequently in "humid" areas in which the mean monthly indoor RH is more than 50% for 4 or more months per year, and rarely in "dry" areas in which this RH is present for 2 mo or less, is likely to apply generally and not only to the province of British Columbia. It is well established that positive skin prick tests are frequent in mild humid places,⁶⁻⁸ and there is already some evidence to suggest that mite sensitivity is less common in areas in which the indoor RH is low for most of the year. Barbee et al.,²⁶ for example, find that positive skin prick tests to *D. farinae* are relatively uncommon in children currently living in the dry climate of Arizona. Another example is the finding of Vervloet et al.²⁷ that there is a decrease in the serum

level of specific IgE antibody to mites in children with asthma after they have been sent to Briacon. This is a city high in the Alps in which the heating season is long and indoor RH is low. However, none of these studies was conducted to establish the prevalence of mite sensitivity, and the methods used have varied, making comparisons with frequencies in other areas difficult. Our study is the first to use a standard technique and a single source of mite extract for testing a group of atopic children, some of whom lived in "humid" areas and some of whom had always resided in a "dry" area.

There are implications for etiologic diagnosis and specific therapy in our findings. First, they suggest that tests for sensitivity to mites should be performed on all atopic subjects from areas that are on the coast or have warm humid summers. Our results indicate that the use of both *D. farinae* and *D. pteronyssinus* extracts should be used as cross-reactivity between the two species is not complete. This finding is in agreement with that of Dailey et al.²⁸ On the other hand, these tests may not be necessary for the routine investigation of patients from semiarid areas or from regions that, although they are humid, have a sufficiently cool summer that requires central heating for most of the year and the mean indoor RH is more than 50% for only 2 of the 12 mo. Another implication is that therapy specific for mites should not be considered for patients who currently live in a "dry" area, and have a positive RAST or skin test to mite, before determining if they previously resided in a "humid" area, a place in which they are more likely to have acquired the sensitivity. There were seven subjects in our study group who were currently living in a "dry" area but had previously resided in a "humid" area. Two of these subjects had a positive prick test to mite. It is likely that symptoms from mites are rare and that mite immunotherapy is seldom indicated in children who live in "dry" areas.

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