

Comparative prevalence of sensitization to common animal, plant and mould allergens in subjects with asthma, or atopic dermatitis and/or allergic rhinitis living in a tropical environment

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Summary

Background and objectives Current information suggests that the expression of allergic diseases is determined by the exposure and nature of the allergen. The objectives of the present study were to determine if the nature of allergenic exposition to animal, plant or fungal allergens influenced the clinical manifestations of atopic dermatitis (AD), allergic rhinitis (AR) or asthma (AS) in patients living in a tropical environment. The prevalence and degree of sensitization to these allergens were analysed by age and gender.

Subjects and methods A total of 1496 atopic cases, grouped according to the primary diagnosis of AD or AR or AS, were skin tested using a standardized allergen panel. Participants were categorized by age groups. The atopic index (AI) and mean wheal diameter (MWD) as well as the prevalence of positive skin tests were determined for each of the patient groups and compared by age groups.

Results The prevalence of atopy as well as the AI and the MWD peaked at 6–15 years of age and declined thereafter. In all the patients tested, the prevalence of sensitization was, in decreasing order; dust mites 94.3%, cockroach 41.5%, pets 31.5%, plant allergens 31.1% and fungal 19.4%. Eight hundred and ninety-three atopic patients were exclusively sensitized only to animal allergens. Of these, 38.4% had AD, 31.3% had AR and 30.5% with AS.

Conclusion These data demonstrate that for patients with AD, AR and AS living in a tropical environment, the prevalence of positive skin reactions to animal allergens is highest followed by plant and fungal allergens. We did not observe any association between the type of allergen and clinical manifestations. The index of atopy was similar for both sexes. The prevalence and degree of sensitization were shown to peak in young adults independent of the allergen in AD and AR patients.

Keywords allergic rhinitis, animal, asthma, atopic dermatitis, plant and mould allergens, tropical environment

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Introduction

The clinical expression of atopy is believed to be associated with the type of allergen exposure [1]. However, the mechanisms determining why some individuals develop allergic rhinitis (AR), asthma (AS) or atopic dermatitis (AD) after they have become sensitized are not understood. In general, the sensitization process may be influenced by several risk factors including maternal smoking, viral infections, air pollution, breastfeeding, inhaled allergens, genetic susceptibility, age of exposure, gender, race and socio-economic status and prenatal exposure [2]. A number of epidemiological studies have demonstrated that sensitization to animal allergens (mites, cat and dog dander and

cockroaches) and to fungal allergens is a factor for the development of AS symptoms [3–7]. Sensitivity and exposure to pollens is a risk factor for the development and triggering of seasonal AR [8]. The expression of AD seems to be more complex than AR and AS, since animal, plant and food allergens can trigger clinical manifestations associated with this disease [9].

If the clinical expression of atopy is in fact driven by the type of allergen exposure, then the geographically specific and non-specific allergens may influence patterns of allergic disease. This influence can also be altered by the quality and quantity of the allergen load, which in conjunction with other variables such as seasonal variation of the allergens and type of housing constitute a very complex issue.

We hypothesize that in tropical environments, the quantity of the allergen load may not vary significantly according to the season and therefore, susceptible individuals are exposed to constantly high concentrations of certain environmental

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triggers. At these levels, allergens may not selectively influence the clinical manifestations of AD, AR or AS. The objective of the present study was to investigate whether for subjects living in a tropical environment, the type of allergen exposure may influence the clinical manifestations of atopy by (i) determining and comparing the frequency of sensitization to animal and plant allergens in atopic subjects living in Ponce, Puerto Rico, and (ii) to investigate if the prevalence and degree of sensitization to these allergens was different in the presence of AS, AR or AD. In addition, the type and degree of sensitization according to age, gender and condition was studied.

Methods

Environment

The City of Ponce is located in southern Puerto Rico. The average summer (June) temperature is 31 °C (79 °F), and the average winter (January) temperature is 20 °C (68 °F). The yearly average rainfall is 40 in, the average year-round temperature is 26 °C (79 °F) and the average humidity is 55% by day and 80% by night. Currently, Puerto Rico has the highest prevalence AS rates in the USA [10].

Subjects and definitions

This was a cross-sectional study, in which the original study population comprising consecutive 2089 subjects residing in the City of Ponce, Puerto Rico were grouped according to a physician's diagnosis of either AD ($n = 793$), AR ($n = 650$) and AS ($n = 646$). Each subject was unrelated and represented different households. The diagnosis of each condition was conducted by several specialists, which included two pulmonologists, a dermatologist, an allergist and several paediatricians according to the established criteria for each condition. After the medical diagnosis was established, the patients were referred from the different outpatient clinics to our laboratory for the study. A total of 1496 subjects met the following inclusion criteria: (1) specialist-based clinical diagnosis and active symptoms of either AD, AR or AS, (2) a positive skin test to at least of one allergen from battery of common animal, plant and fungal allergens, (3) a valid skin test (subject responded to the histamine positive control with a weal greater than 3 mm and without a skin reaction to the negative control), (4) completion of a self-applied questionnaire composed of close-ended items on demographics, a family history of allergy and environmental tobacco exposures and (5) not taking medications, such as antihistamines, which could interfere with the skin prick tests.

A total of 593 (28.4%) subjects did not meet the inclusion criteria. There were no significant differences between the gender distributions. The mean age difference between the study subjects and those excluded from the study was 2.7 years (respectively 20.4 ± 16.9 and 23.2 ± 21.6 , pairwise $P = 0.002$). Exclusive allergen reactions to either animal, plant or fungal allergens are in relation to those allergens tested in the present study. Prior to testing, all the participants were asked to read and sign the Institutional Review Board approved informed consent forms. The skin

testing was initiated in August 1996 and completed in August 2001. Given the number of patients obtained for the three atopic conditions, the minimum differences detectable between diagnostic groups in the proportions of positive skin tests at α 0.05 and 80% power is 7%.

Dust mite allergen extracts for skin testing

Extracts from the domestic mites *Blomia tropicalis* (Bt) and *Euroglyphus maynei* (Em) are not commercially available and were prepared as previously reported [11]. A total of 1 g of food-free Bt and Em bodies were extracted in 20 mL of 0.2 M ammonium bicarbonate. The mixture was then placed in a beaker and sonicated for 15 min, on ice, at full output for 10 cycles, and placed in a refrigerated cabinet and incubated overnight under constant agitation. The extract was centrifuged at $200 \times g$ for 1 h, and the resulting supernatant extensively dialysed against water sterilized using a 0.22 µm pore size filter with a 3000 kDa exclusion limit. After this, the extract was supplemented with 50% sterile glycerol. Mite cultures of Em were kindly provided by Dr B. Hart and extracts were prepared as described.

Skin prick testing

Skin-prick tests were performed in the volar surface of the right arm by a trained nurse according to Pepys [12]. Volunteers were tested using standardized commercial glycerinated extracts as previously reported [11]. All the patients were negative when the skin was tested with a culture medium extract. The skin reaction was recorded at 15 min. The mean of the major diameter and its perpendicular for the weal were measured and a skin reaction was considered positive if it had a weal equal to or greater than 3 mm in mean diameters. Positive (histamine 1 mg/mL) and negative (sterile PBS in 50% glycerol) controls, and an extract of the mite culture growth medium were included in the skin testing. For the prick tests, disposable acrylic copolymer needles were used (Morrow Brown, Oakhurst, NJ, USA). All the participants were tested using the same allergen lot and preparations. The following glycerinated extracts, which were purchased from a single vendor (Hollister Stier, Spokane, WA, USA) with the exception of the dust mites Bt and Em, were tested in the study population: house dust mites *Dermatophagoides pteronyssinus*, *D. farinae*, Bt and Em, American cockroach *Periplaneta americana*, cat and dog dander. The general composition of the allergen mixes was as follows: Tree pollen 1:10 v/w: equal parts of Olaceae *Fraxinus americana* (White Ash), Fagaceae *Fagus grandifolia* (American Beech), Betulaceae *Betula nigra* (River Birch), Juglandaceae *Juglans nigra* (Black Walnut), Rubiaceae *Populus deltoides* (Common Cottonwood), Ulmaceae *Ulmus americana* (American Elm), Juglandaceae *Carya ovata* (Shagbark Hickory), Aceraceae *Acer saccharum* (Hard Maple), Fagaceae *Quercus rubra* (Red Oak), Platanaceae *Platanus occidentalis* (American Sycamore) and Salicaceae *Salix nigra* (Marsh Black Willow). Weed: 1:10 w/v: equal parts of Asteraceae *Xanthium strumarium* (Cocklebur), Chenopodiaceae *Kochia scorparia* (Kochia), Chenopodiaceae *Chenopodium album* (Lamb's Quarters Marshelder), Chenopodiaceae *Monolepis pusilla* (Small Poverty-weed), Asteraceae

Iva ciliata (True Marshelder), Compositae *Ambrosia trifida* and *Ambrosia eliator* (Ragweed mix), Amaranthaceae *Amaranthus retroflexus* (Rough Red Root), Chenopodiaceae *Salsola tragus* (Russian Thistle), Sagebrush Mix Asteraceae *Artemisia tridentata* (Common Sagebrush), *Artemisia ludoviciana* (Prairie Sage) and *Artemisia vulgaris* (Dark Mugwort), Dock Sorrel Mix Polygonaceae *Rumex acetosella* (Sheep Sorrel), Chenopodiaceae *Rumex hymenosepalus* (Curley dock) and Polygonaceae *Rumex crispus* (Yellow Dock) and Amaranthaceae *Amaranthus tuberculatus* (Western Waterhemp). Grass 1:10 w/v: equal parts of Poaceae *Poa pratensis* (Kentucky Blue Grass), *Dactylis glomerata* (Orchard Grass), *Agrostis alba* (Redtop), *Phleum pratense* (Timothy), *Anthoxanthum odoratum* (Sweet Vernal Grass), *Cynodon dactylon* (Bermuda Grass) and *Cynodon dactylon* (Johnson Grass). Mould mix A: 1:10 w/v: equal parts of *Botrytis cinerea*, *Chaetomium indicum*, *Epicoccum nigrum*, *Fusarium vasinfectum*, *Geotrichum candidum*, *Helminthosporium interseminatum*, *Monilia sitophila*, *Mucor racemosus*, *Phoma herbarum*, *Penicillium mix*, *Pullularia pullulans*, *Rhizopus nigricans*, *Rhodotorula glutinis* and *Saccharomyces cerevisiae*. Mould mix B:1:10 w/v: equal parts of *Trichophyton schenitiei*, *Cephalothecium reseau*, *Hormodendrum cladosporioides*, *Neurospora crassa*, *Streptomyces griseous*, *Scopulariopsis brevaucalis*, *Curvularia spicifera*, *Penicillium roseum*, *Mycogone* sp, *Nigrospora spherica*, *Paecilomyces varioti*, *Spondylocadium* sp. *Stemphylium botryosum*, *Trichoderma viride* and *Trichosporon aquatile*. These allergen mixes have been used in previous studies conducted in Puerto Rico [13].

Data entry and analysis

Data were computerized into a commercial statistical software (Stata, Stata Corporation, College Station, TX, USA). The participants were divided into three major groups according to the primary reason for the specialist consultation; AD, AR or AS. Participants were categorized into six age groups (0–5, 6–15, 16–25, 26–45, 46–65 and >65 years) similar to Boulet et al. [14] for comparison purposes. Participants were further subdivided according to sensitization to animal allergens, plant allergens and fungal allergens. Positive to animal allergens were skin reactions to house dust mites, pets (dogs and cats) and cockroaches, while to plant allergens were considered pollen from grasses, trees and weeds. Positive skin reactions to fungal allergens were considered those skin reactions positive to moulds only. The AI was defined as the total number of positive skin tests out of 12 allergens. The mean weal diameter (MWD) was also calculated for all the participants on the skin reactions. All continuous variables were tested for normality, and are expressed as the mean $\pm$ standard error. The ANOVA with Tukey's tests for pairwise comparisons was used. We compared the different diagnostic groups and age groups using an ANOVA with a Tukey's test to determine which groups were significantly different from each other. The comparison of categorical variables was made by using the χ^2 statistic. Graphical representation of data included mean values $\pm$ SEM. Correspondence analysis was used to illustrate graphically a contingency table of association between the type of allergen and diagnosis of AD, AR and AS. By convention, the level of significance was established at 0.05.

Results

Study population

A total of 1496 participants were considered atopic (71.6%), and of these, 37.0% ($n = 554$) had AD, 31.8% ($n = 476$) AR and 31.1% ($n = 466$) were asthmatics. In all diagnostic groups, patients between 6 and 15 years were the most numerous age group, and significant differences were observed between age groups only. The age distribution of the allergic subjects was: category <6 years 18.1% ($n = 271$); 6–15 years, 33.8% ($n = 506$); 16–25 years, 18.3% ($n = 274$); 25–45 years, 19.6% ($n = 293$); 46–65 years, 8.6% ($n = 128$) and over 66 years, 1.6% ($n = 24$). The mean age of the allergic patients was 20.4 ± 17.0 years of age; AD was 21.0 ± 18.5 years, AR was 21.7 ± 17.6 years and AS was 19.6 ± 15.0 years. No significant differences between the ages in each diagnosis category were found. In the study population, 53.7% ($n = 803$) were women and 46.3% ($n = 693$) were men. Significant differences in age were observed between female and male subjects (respectively 23.3 ± 17.7 and 17.0 ± 15.4 , pairwise $P > 0.001$). No significant differences in age were found between diagnostic groups.

Prevalence and degree of sensitization to allergen groups

The skin reactivity pattern observed in subjects with AR, AD and AS was similar for all allergens tested (Table 1). An overwhelming majority of the patients belonging to each diagnostic group were sensitized to animal allergens. Within the animal allergens, the highest sensitization rates were observed to dust mites followed by cockroach and pet sensitivity. A lower skin reactivity was detected to plant allergens, and to fungal allergens.

The pattern of exclusive skin reactions to the different allergen groups for each of the diagnosis groups is summarized in Table 2. The exclusive reactivity to animal

Table 1. Prevalence of sensitization in skin positive subjects to common allergens according to diagnosis

Allergens	Atopic dermatitis (%)	Allergic rhinitis (%)	Asthma (%)
<i>Animal</i>	94.2	94.7	94.2
House dust mites*	87.4	88.2	87.5
<i>Dermatophagoides pteronyssinus</i>	76.2	72.7	75.3
<i>D. farinae</i>	72.4	71.0	76.1
<i>Blomia tropicalis</i>	68.2	66.2	69.5
<i>Euroglyphus maynei</i>	65.0	62.6	69.5
<i>Pets</i>	30.9	32.7	31.0
Dog	12.3	12.4	13.0
Cat	23.1	26.7	23.0
Cockroach (<i>Periplaneta americana</i>)	41.2	43.5	39.9
<i>Plants</i>	29.2	31.3	32.8
Grass pollen	16.9	19.1	19.3
Tree pollen	12.6	14.9	12.0
Weed pollen	10.7	12.4	16.7
<i>Fungal</i>	19.0	21.0	18.2
Mould mix A	12.4	12.6	10.7
Mould mix B	10.2	12.4	11.1

*Positive reaction to at least one out of four mite species.

Table 2. Number and percentage of subjects exclusively sensitized either to *animal*, *plant* or to *fungal* allergens

	Atopic dermatitis	Allergic rhinitis	Asthma	Total
<i>Skin reactions to animal allergens</i>				
Number of subjects with exclusive skin reactions animal allergens from each diagnosis group	343	279	271	893
Percent of subjects with exclusive skin reactions to animal allergens from each diagnosis group	95.0% (343/361)	94.3% (279/296)	94.0% (271/289)	
Percent of subjects with exclusive skin reactions to animal allergens of total	38.4% (343/893)	31.2% (279/893)	30.5% (271/893)	
<i>Skin reactions to plant allergens</i>				
Number of subjects with exclusive skin reactions plant allergens from each diagnosis group	13	11	16	40
Percent of subjects with exclusive skin reactions to plant from each diagnosis group	3.6% (13/361)	3.7% (11/296)	5.5% (16/289)	
Percent of subjects with exclusive skin reactions to plant of total	34.2% (13/38)	29.0% (11/38)	32.1% (16/38)	
<i>Skin reactions to fungal allergens</i>				
Number of subjects with exclusive skin reactions to fungal allergens from each diagnosis group	5	8	2	15
Percent of subjects with exclusive skin reactions to fungal allergens from each diagnosis group	1.4% (5/361)	2.7% (8/296)	0.7% (2/289)	
Percent of subjects with exclusive skin reactions to fungal allergens of total	33.3% (5/15)	53.3% (8/15)	13.3% (2/15)	
Total	361	296	289	946

allergens was the highest in all the diagnosis groups and ranged from 38.4% in AD, 31.2% in AR to 30.5% in AS. Lower but similar rates in each diagnosis group were observed for exclusive reactions to plant allergens. In the case of exclusive skin reactions to fungal allergens, there was an increased prevalence of skin reactivity according to diagnosis from 13.3% in AS patients, to 33.3% in AD, and reaching 53.3% in AR.

Mean AI and MWD according to age, sex and diagnosis

The mean AI was similar in all the diagnoses and no significant differences were obtained when Tukey's test was conducted (AS = 4.8 ± 0.09 , AD = 4.8 ± 0.11 and AR = 4.7 ± 0.09 , $P = 0.85$). Similar results were obtained when the MWD was compared among AS, AD and AR (respectively $n = 554$, 2.7 ± 0.06 ; $n = 476$, 2.6 ± 0.07 and $n = 466$, 2.7 ± 0.06 , pairwise $P = 0.55$). The indexes were also compared within the various age groups. The 0–5 years age group had significantly less AI than the 6–15 and 16–25 years age group ($n = 271$, 4.0 ± 0.1 ; $n = 506$, 4.9 ± 0.1 and $n = 274$, 5.4 ± 0.1 , pairwise $P < 0.0001$). The mean AI in women was similar to that obtained in men (4.8 ± 2.4 and 4.7 ± 2.1 , pairwise $P = 0.7$). In contrast, women had a higher MWD than men (2.8 ± 1.7 and 2.5 ± 1.3 , pairwise $P < 0.0001$). Men and women were analysed separately to detect if there were differences in the mean AI and MWD according to age. We observed that subjects in the age groups 6–15 and 16–25 years had significant differences when compared with subjects in the 0–6- and 45–64-year-old groups, but not with patients over 66 years of age. No significant differences were obtained in both indexes when compared between AD, AR and AS (4.7 ± 2.1 , 4.8 ± 2.5 , 4.8 ± 2.3 , $P = 0.8$). Similar results were observed for the MWD (2.7 ± 1.5 , 2.6 ± 1.5 , 2.7 ± 1.6 , $P = 0.5$) and the results are shown in Table 3. The weal mean diameter was also compared between gender and age groups. It was observed that women had a higher value than men only in the 6–15 years age group (5.2 ± 2.2 and 4.8 ± 2.0 , pairwise $P < 0.05$).

In patients with AD, the highest mean AI was observed in the 16–25 years group, and significant differences were obtained when the 6–15- and 16–25-year-old groups were compared with the 0–5 years age group (Fig. 1). No

significant differences were observed in the AS patients. In patients with AS, significant differences were obtained between the 16–25- and the 0–6-year-old age groups. In the case of the MWD, there were significant differences between the age groups.

The AI in subjects exclusively sensitized to animal allergens was significantly higher than in those sensitized exclusively to plant allergens (4.3 ± 0.06 , $n = 893$ and 1.55 , $n = 38$, $P < 0.0001$), and to fungal allergens (4.3 ± 0.06 , $n = 893$ and 1.5 ± 0.16 , $n = 15$, $P > 0.0001$). In the case of the weal diameter of the skin prick test, significant differences were observed between those exclusively sensitized to animal allergens and those sensitized exclusively to plant allergens ($2.5 \pm 0.42 \text{ mm}^2$, $n = 893$ and $0.5 \pm 0.09 \text{ mm}^2$, $n = 38$, $P\text{-value} < 0.0000$), and to fungal allergens ($2.5 \pm 0.42 \text{ mm}^2$, $n = 893$ and $0.8 \pm 0.07 \text{ mm}^2$, $n = 15$, $P\text{-value} < 0.0000$). The adjusted coefficient of determination (r^2) for AI and weal by age group, gender and by diagnosis ranged between 73% and 87%.

Prevalence and degree of sensitization to allergens according to age, and diagnosis

In general, sensitivity to animal allergens was similar in all the age groups in each of the diagnosis groups, and the maximal prevalence was observed in the 16–25 years age group. In decreasing order, the rank according to the frequency of the most relevant positive skin reactions was as follows: dust

Table 3. Mean atopic index and mean weal diameter according to age

Age (years)	<i>n</i>	Mean atopic index	Tukey's*	Mean weal diameter	Tukey's*
(A) 0–5 [†]	272	$4.0 \pm 0.12^{\ddagger}$	B, C, D	2.0 ± 0.074	B, C, D
(B) 6–15	507	$4.9 \pm .09$		2.7 ± 0.06	C, F
(C) 16–25	275	$5.4 \pm .12$		3.3 ± 0.09	D, E
(D) 26–45	294	$4.9 \pm .15$	E	2.8 ± 0.09	E
(E) 46–65	129	$4.3 \pm .23$		2.2 ± 0.12	
(F) ≥ 66	24	$4.5 \pm .51$		2.3 ± 0.25	

*Tukey's test: significant comparisons ($P < 0.05$). [†]Age groups. [‡]SE.

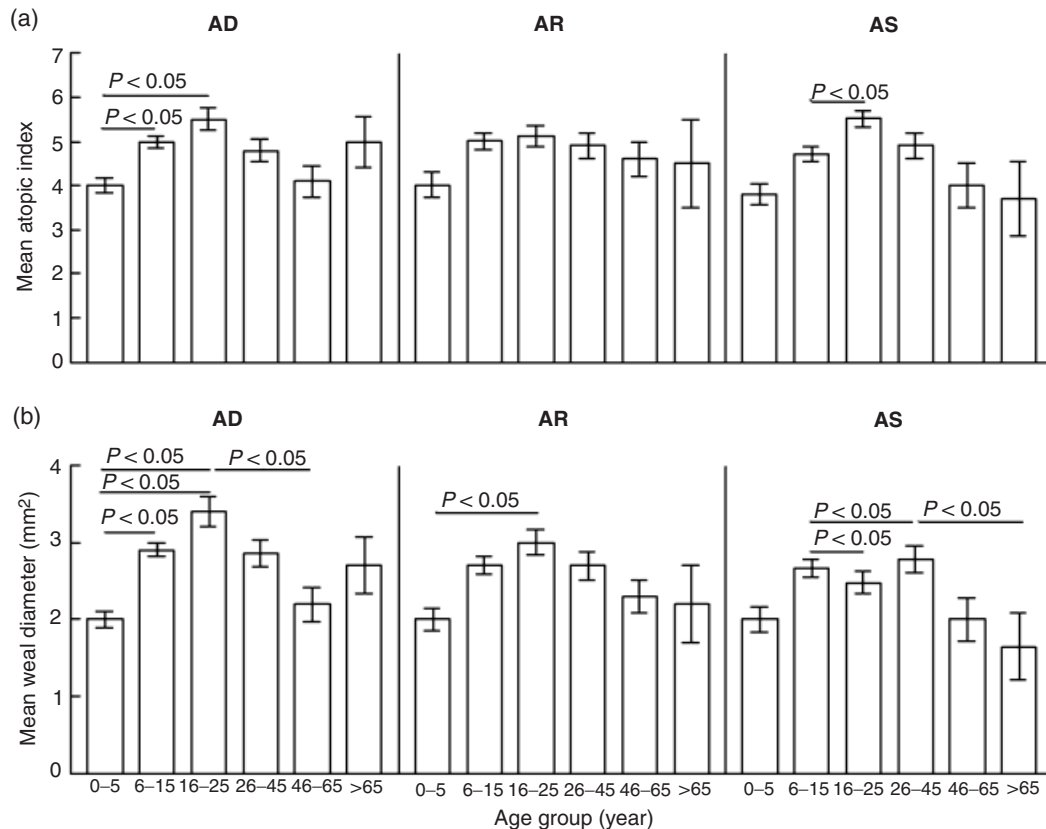


Fig. 1. Comparison by age of the mean atopic index and mean weal diameter among subjects with diagnosis of atopic dermatitis (AD), allergic rhinitis (AR) and asthma (AS). (a) Illustrates the age comparison of the mean atopic index in each diagnosis group. In patients with AD and AS, the maxima allergic peak as obtained in the 16–25 years. (b) Summarizes the age comparison of the mean weal index in each diagnosis group. Patients with AD and AR had their maxima mean weal index in the 16–25 years, while AS was at 26–45 years.

mites (*D. pteronyssinus*, *D. farinae*, Bt, Em and *P. americana*). A lower but similar pattern was observed for the prevalence of skin reactions to plant allergens, and maximal prevalence was detected in patients over 45 years of age. The maximal prevalence of positive skin reactions to fungal allergens was similar to the one observed for plant allergens.

The prevalence of skin reactions was also analysed by age and diagnosis (Fig. 2). In general, it was observed that the peak prevalence of positive skin reactions was in the 6–15 years age category. In this age group, the highest prevalence of positive skin reactions to domestic mites was detected in patients with AD followed by AR and AS, and there was a tendency to decrease the prevalence of positive skin reactions as age increased. Allergy to pets showed a different pattern than the one observed for domestic mites. In the AR and AD patients, there was a bimodal tendency reaching maximal prevalence at the 6–15 and 26–45 year age groups. In contrast, in AS patients there was a normal distribution curve reaching the maximal prevalence at the 16–25 year age group. Roaches showed a similar pattern with pets. However, it was noted that in allergy to moulds, there was a bi-modal pattern and the highest prevalence was observed in the 6–15 and 26–45 years age groups in AR and AD. Patients with AS also showed a bi-modal pattern and the maximal prevalence was detected in the 26–45 year age group. In the case of pollens, the pattern of skin reactivity was also similar to the

one observed in moulds, with the exception of AS, which had maximal prevalence in the 6–15 year age group. Figure 3 shows the lack of association of allergic diseases with a particular allergen.

Discussion

Our results show that the majority of the clinically active atopic individuals were sensitized to animal allergens, and the prevalence of positive skin reactions in subjects with AD, AR and AS to these allergens was similar among the diagnoses. We found that the prevalence of positive skin reactions to plant allergens were lower than animal allergens, and the pattern of positive skin reactions was similar to that observed in animal allergens. The prevalence of positive to fungal allergens was the lowest when compared with plant and animal allergens, and the sensitization pattern was similar as described. The exclusive prevalence of positive skin reactions to animal, and to plant allergens was similar in all in the diagnosis groups. We did not detect any associations between diagnosis and the type of exposure. In general, the prevalence of skin reactions to the various allergens tested, as well as the mean topic and weal indexes peaked at 6–15 years decreasing thereafter. Patients with AS showed a peak in both indexes at ages 6–15 and 26–45 years.

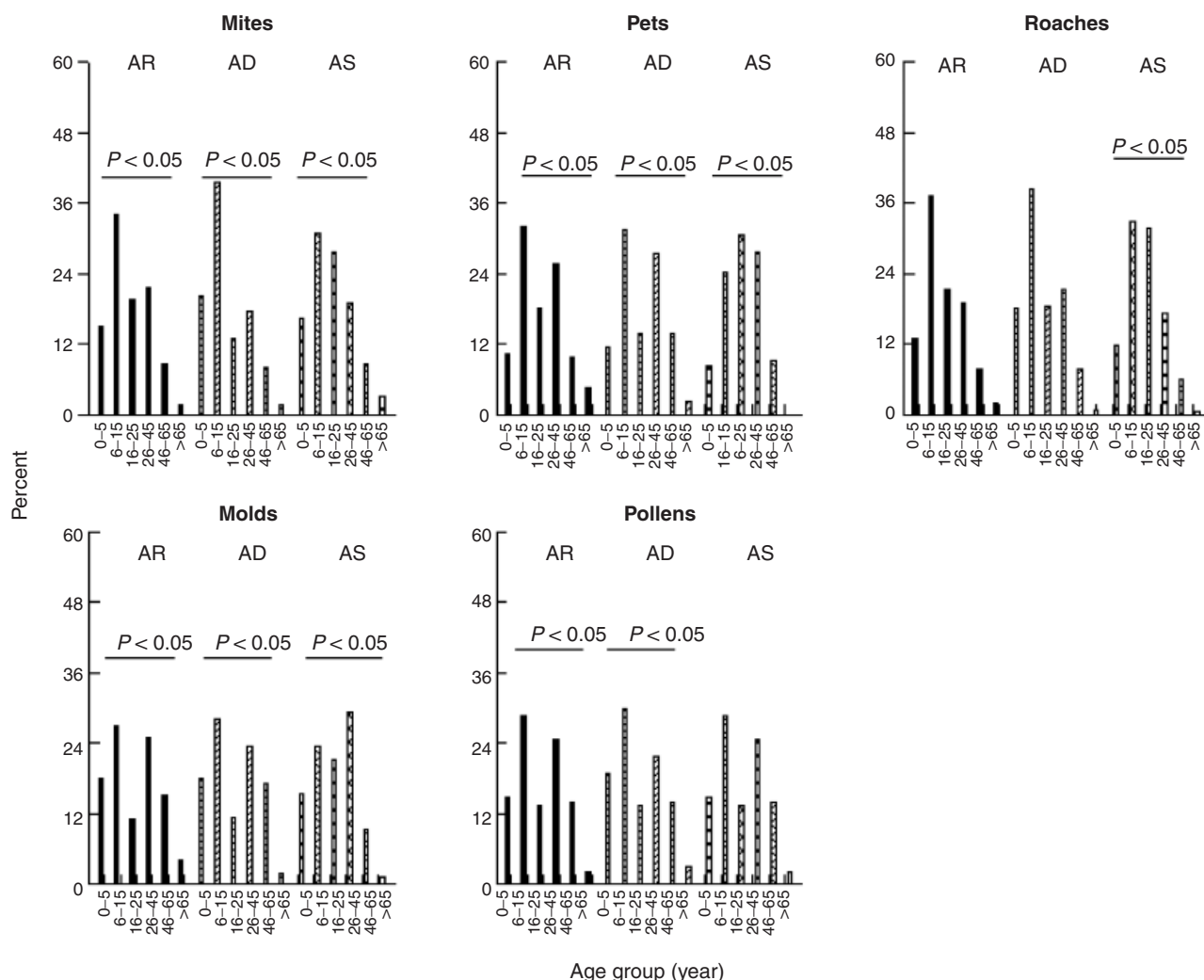


Fig. 2. Comparison of the skin reactivity by allergen and age for each diagnosis group. Solid bars represent allergic rhinitis (AR) patients, hatched bars are atopic dermatitis (AD) patients and cross-hatched are asthma (AS) patients.

As in other atopic conditions, clinical manifestations of AR have many environmental triggers including pollens, moulds, dust mites and animal dander [15]. Of these exposures, pollen has been overwhelmingly linked with the development and clinical expression of this disease [14, 16]. Other authors have provided evidence that pollen is not the most important trigger. Linneberg et al. [17] showed that AR symptoms were linked to exposure to pollen and also to furry animals, and house dust. In AS, available data indicate that the development and clinical manifestations of the disease are mostly associated with animal allergens including dust mites, cockroaches and pets [16, 18]. In the case of AD, exposures to food and inhalant allergens as well as mites and moulds are involved in the triggering of the clinical manifestations [19]. Together, these data suggest that the development of allergic disease is an extremely complex process and may not just be under the influence of exposures to only animal or plant allergen groups.

Evidence of the geographic variation in allergens, both qualitatively and quantitatively, influencing the prevalence of atopic disease has been produced by several multi-site studies. In one, Burr et al. [20] demonstrated that the prevalence of

AS in children had a geographical variation; New Zealand had the highest prevalence and Sweden the lowest. The authors proposed that the differential exposure to animal allergens was a possible factor in this variation. Similar results have been obtained for animal allergens, especially domestic mites [21–23]. In another study, Lewis et al. [24] demonstrated in temperate regions that levels of pollen were linked to plant flowering seasons, with trees releasing pollen in the spring, grasses in the early summer and weeds in the later summer and fall, and their concentrations can vary according to the geographical region. However, these studies have been conducted in geographic regions with well-defined seasons. Therefore, it would be difficult to extrapolate these results to tropical environments where seasonal changes are minimal. Our data suggest that the influence of environmental triggers in tropical areas, in particular allergens, cannot support the evidence that the type of allergen may influence the clinical manifestations of allergic disease, especially AR.

In our study, we found equivalent prevalence of exclusive positive skin reactions to animal, and to plant allergens (pollens) in AR, AD and AS. These results are in contrast with those reported by Boulet et al. [14]. The authors found a

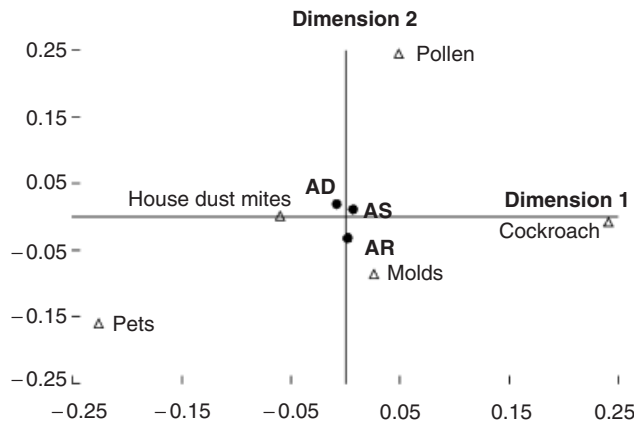


Fig. 3. Association between allergy clinical manifestations according to the type of allergen. Correspondence analysis results demonstrate an absence of specific a correlation between atopic diagnoses and different allergen exposures. All three conditions (allergic rhinitis (AR), asthma (AS) and atopic dermatitis (AD)) remain in the centre of the axis without any clear correlation with animal, plant or fungal allergens.

higher prevalence of positive skin reactions to plant allergens in AR patients than asthmatics.

Our results may be explained in part by the geographic differences between the Nordic and tropical environments. In our population, constant allergen exposure, a product of minimal seasonal changes, may lead to similar sensitization rates between animal and plant allergens in susceptible individuals. Therefore, the total allergen load, composed of several allergen types, would be rather constant during the year. It has been demonstrated in a tropical environment that dust mite allergens Der f 1 and Der p 1 show minimal variations [25]. In contrast, in environments with defined season changes, allergen loads, especially pollens, have seasonality patterns and possibly influence the development and symptoms of AR. Kulig et al. [26] conducted a prospective birth cohort study and showed that the development of AR required at least two seasons of pollen exposure before manifestation of seasonal AR.

In addition to the geographical differences, there are other factors that could influence the development and expression of allergic disease. First, the type of housing may influence the quality of allergenic exposures. In a tropical environment, houses have high cross-ventilation, allowing high air flow from the outdoors to the indoor. This would be relevant for the expression of allergic disease because exposures to plant (outdoor) allergens and animal (indoor) allergens would be similar. Our results show that sensitization rates exclusive to plant allergens were similar between AR, AD and AS patients. Second, it is possible that chronic exposures to other environmental irritants such as bacterial endotoxins and serine proteases may influence the development and symptoms of allergic disease. Specific receptors for endotoxin and serine proteases have been described [27, 28] and associated with AS [29]. Third, genetic influences of the population studied may be an important factor. Recent data have shed light on a series of candidate genes involved in the susceptibility to atopic diseases [30–32].

The association between skin reactivity, age and diagnosis was also analysed. Our data showed that for most of the

allergens tested, skin reactivity rose significantly during childhood, was significantly higher in the 6–15 years age group and progressively decreased between 16 and 75 years of age. Our results are in concert with those previously reported [33, 34].

The limitations of the present study are those associated with the study design, and the findings of this study are limited to those patients with a main complaint and symptoms associated with that particular diagnosis. It may be possible that mild or milder cases of each condition may not seek medical attention and may be under-represented. However, we do not expect to have an important under-representation of moderate to more severe cases.

In conclusion, our study shows that in a tropical environment, the clinical expression of allergy may not be influenced by the type of allergen used in the present study. The prevalence of exclusive skin reactions to animal allergens is the most common one and patients with AD, AR or AS had similar rates of sensitivity. Exclusive sensitization to plant allergens was low but had similar rates for each diagnosis group.

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