

Spatial and Temporal Distribution of House Dust Mite (Astigmata: Pyroglyphidae) Allergens Der p 1 and Der f 1 in Barbadian Homes

KATHLEEN C. BARNES,¹ ENRIQUE FERNÁNDEZ-CALDAS,² WALTER L. TRUDEAU,²
DAVID E. MILNE,³ AND RICHARD J. BRENNER³

J. Med. Entomol. 34(2): 212–218 (1997)

ABSTRACT House features contribute to house dust mite abundance and, therefore, exposure to mite allergens. Our study assessed the hypothesis that modernization of the domestic environment in a tropical setting may lead to a level of allergen from the house dust mites *Dermatophagoides pteronyssinus* (Trouessart) and *D. farinae* Hughes that previously has been defined clinically as at risk for people who suffer from allergic disease. Allergen (Der p 1 and Der f 1) levels were measured at 4 sites (mattress, bedroom floor, living room floor, and furniture) in 17 houses in Barbados during dry and rainy seasons. Der p 1 (17 of 17 homes) at all 4 sites did not vary significantly from the dry to rainy season. Allergen levels varied according to site, and were highest in living room furniture in both seasons (geometric mean 40.37 and 64.17 $\mu\text{g/g}$, respectively). Concentration of Der p 1 allergens were higher in concrete than in wood or mixed concrete and wood houses. Der f 1 (9 of 17 homes) levels were lower than Der p 1 by 1/1,000 (both seasons). Results indicate that season is less important in regard to levels of Der p 1 than house construction and confirm other studies that implicate *D. pteronyssinus* as a more abundant source of allergen than *D. farinae* in this tropical setting.

KEY WORDS *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, allergens, Barbados, house construction, weather

AEROALLERGENS PRODUCED FROM house dust mites are believed to be universally responsible for atopic asthma, probably as a result of prolonged exposure in the indoor environment (Platts-Mills and de Weck 1989, Platts-Mills et al. 1992). Allergens from the house dust mites *Dermatophagoides pteronyssinus* (Trouessart) and *D. farinae* Hughes are perhaps 2 of the most important allergens worldwide (Platts-Mills and de Weck 1989, Pollart et al. 1989, Platts-Mills et al. 1992). The major allergens of the genus *Dermatophagoides*, or group I allergens (Der p 1 and Der f 1), have been well characterized (Chapman and Platts-Mills 1980, Lind 1985, Holck et al. 1986). Platts-Mills et al. (1989) concluded that concentrations of house dust mite allergen $\geq 2 \mu\text{g/g}$ of dust increase the risk of sensitization in children who suffer from allergic disease and subsequently contribute to the overall prevalence of allergy. This conclusion was

supported by subsequent studies (Lau et al. 1989, Sporik et al. 1990, Vervloet et al. 1991).

Studies examining the spatial and temporal distribution of *Dermatophagoides* spp. have been conducted in temperate climates in developed societies (van Bronswijk 1973, Murray and Zuk 1979, Tovey et al. 1981, Platts-Mills et al. 1987, Lau et al. 1989) and in tropical climates in developing societies (Buchanan and Jones 1972, Dowse et al. 1985). In some cases, researchers have focused on indoor climate control factors (e.g., air conditioning, central heating) and the effect on house dust mite allergen levels (Murray and Zuk 1979, Platts-Mills et al. 1987). Others have highlighted the importance of changes in life style and the introduction of material objects (e.g., cotton blankets) into the domestic environment (Pearson and Cunningham 1973, Dowse et al. 1985, Massicot and Cohen 1986). Few studies have focused on interrelationships among architectural features of the dwelling, weather, and house dust mite allergen levels.

Pearson and Cunningham (1973) found house dust to be an important allergen for asthmatics in Barbados. The most abundant species of house dust mites identified in Barbadian house dust was *D. pteronyssinus*. A relationship was found between the concentration of *D. pteronyssinus* allergen in mattresses and allergy to that species, and

This article reports the results of research only. Mention of a proprietary product does not constitute an endorsement or a recommendation for its use by USDA.

¹Departments of Anthropology and Entomology, University of Florida, Gainesville, FL 32611.

²Division of Allergy and Immunology, VA Hospital, (VAR 111D) 1300 30th Street North, Tampa, FL 33612.

³Medical and Veterinary Entomology Laboratory, USDA-ARS, Gainesville, FL 32604.

they concluded that the predominantly wooden houses situated on coral or concrete blocks provided conditions that were "... especially suitable for the growth of many mite species, particularly *D. pteronyssinus*." As a consequence of increasing modernization, the structural design of the domestic dwelling in Barbados has undergone rapid transformation (Dann 1984, Potter 1986). All-timber dwellings have decreased from nearly 90% in the 1950s (Lowenthal 1957) to $\approx 40\%$ in 1990 (Anonymous 1994) and are being replaced with concrete.

The objectives of our study were to determine differences in spatial and temporal distribution of house dust mites in an environment situated in a tropical climate and undergoing rapid infrastructural transition, and to correlate allergen levels with structural features in the domestic dwelling. The overall purpose was to determine the role that housing construction plays on the distribution of house dust mite allergens in the domestic environment, given that the outdoor climate in terms of relative humidity and temperature is ideal for mite growth and proliferation.

Materials and Methods

Participating Households. Five villages that represented the main topographical regions of the island were sampled from January to December 1991. Following approval by the University of Florida Institutional Review Board, 4 homes were selected randomly in each village. Three homes (1 mixed and 2 concrete) were deleted from assessment because samples were damaged during shipment to the United States, leaving a total of 17 homes. Of those 17 households, 3 refused to continue participating at the time of the 2nd visit, resulting in only 14 homes sampled during the rainy season. Eight homes (47.0%) were all wood, 7 (41.2%) were mixed (concrete and wood), and 2 (11.8%) were entirely concrete. The mean household density (number of persons per number of rooms) was 1.5 (range, 0.5–3.0), which is consistent with national census figures.

Participant observation and an ethnographic survey were conducted in each home and in each village to collect the following data: household density; architectural features of the home (construction, age of home, number of bedrooms); and characteristics of the vacuum sites (e.g., age of furniture and mattresses, number of beds per bedroom, presence of carpeting). Information was updated during the 2nd visit.

Collection of Dust Samples. Dust samples were collected biannually, during the dry (January–May) and rainy (August–November) seasons, by a standard procedure (Platts-Mills and de Weck 1989) using a hand-held vacuum cleaner with a built-in collection chamber. Samples were collected from 4 sites in each home, including the bedroom mattress, the bedroom corner (a rug or car-

peted corner if present), the most frequently used upholstered piece of furniture in the living room, and a corner in the living room (preferably a rug or carpeted corner). Vacuuming lasted 5 min at each site and included 1 m² of surface area. Filters containing the dust samples were placed in a zip-lock bag and stored at -20°C until analyzed.

Quantitation of Mite Allergens. Dust samples were processed (Fernandez-Caldas et al. 1993) and Der p 1 and Der f 1 concentrations were determined by 2-site monoclonal antibody radioimmunoassays (Chapman et al. 1987, Swanson et al. 1989). Control curves constructed from doubling dilutions of *D. pteronyssinus* and *D. farinae* contained from 250 to 0.5 ng/ml Der p 1 and Der f 1. Monoclonal antibodies (including 4Cl which recognizes a cross-reacting epitope on both Der p 1 and Der f 1 and is used at the 2nd antibody in both assays) were kindly provided by Martin Chapman (University of Virginia, Charlottesville).

Statistical Analysis. Data from the interviews and dust samples were coded and entered into a database program (Symantec 1991). Frequency distributions and bivariate analyses (Pearson R, chi-square, *t*-tests, and analysis of variance [ANOVA]) were produced using logistic analysis procedures (SAS Institute 1988). Least-squares means, a general linear model (GLM) ranked procedure (Searle et al. 1980), was used to investigate the interaction of independent variables (dust collection site, house type, and season) and allergen concentrations.

Results

Der p 1 and Der f 1 allergen concentrations detected in the 4 sites from the 17 houses are shown in Table 1. Allergen levels are expressed in different units of measure ($\mu\text{g/g}$ and ng/g , respectively) because the concentrations of Der f 1 allergens were lower than Der p 1 by 1,000 times. Der p 1 allergens were present in 17 of 17 (100%) of the homes sampled, and Der f 1 allergens were collected from 12 of 17 (71%) of the homes. Der p 1 allergen levels were $>2 \mu\text{g/g}$ of dust in at least 1 of the 4 sites tested in 13 of 17 (76%) homes in the dry season and 10 of 14 (71%) homes in the rainy season; however, Der f 1 allergens were $<2 \mu\text{g/g}$ at all sites in each home in which they were detected (data not shown). Der f 1 was absent in 8 of 17 (47%) homes in the dry season and 5 of 14 (29%) homes in the rainy season.

After correcting for the absence of samples in 3 of 17 homes during the rainy season, GLM was constructed for both Der p 1 and Der f 1 on ranks (SAS Institute, 1988) of allergen concentration (Conover and Iman 1981) with means for season separated by the Tukey test. There were no significant differences among any of the levels of Der p 1 or Der f 1 in each of the 4 locations in the home according to season.

Table 1. Concentration of Der p 1 and Der f 1 allergens in 17 Barbadian homes

Collection site	Der p 1			Der f 1		
	No. times present	Geometric mean $\pm$ SD allergen, $\mu\text{g/g}$ dust	Range	No. times present	Geometric mean $\pm$ SD allergen, ng/g dust	Range
Dry season						
Mattress	16 of 16 ^a	15.8 $\pm$ 37.4	0.13–120	5 of 16 ^a	11.1 $\pm$ 19.6	0–44
Bedroom floor	17 of 17	4.2 $\pm$ 11.2	0.02–44.8	4 of 17	10.7 $\pm$ 19.9	0–50
Living room floor	16 of 16	1.3 $\pm$ 1.3	0.13–5.05	7 of 16	17.9 $\pm$ 23.9	0–60
Living room furniture	17 of 17	40.4 $\pm$ 78.2	0.02–284.2	5 of 17	19.3 $\pm$ 38.5	0–148
Rainy season						
Mattress	14 of 14 ^b	3.7 $\pm$ 6.8	0.21–23.16	7 of 14 ^b	23.0 $\pm$ 27.9	0–68
Bedroom floor	13 of 13 ^{a,b}	0.8 $\pm$ 0.7	0.14–2.74	4 of 13 ^{a,b}	16.9 $\pm$ 27.3	0–72
Living room floor	14 of 14 ^b	10.0 $\pm$ 33.2	0.02–125	4 of 14 ^b	15.0 $\pm$ 24.8	0–60
Living room furniture	14 of 14 ^b	64.2 $\pm$ 90.4	0.15–252	4 of 14 ^b	11.1 $\pm$ 21.9	0–60

^a One sample was insufficient to determine mite allergen level.

^b Samples could not be repeated in 3 homes during the rainy season.

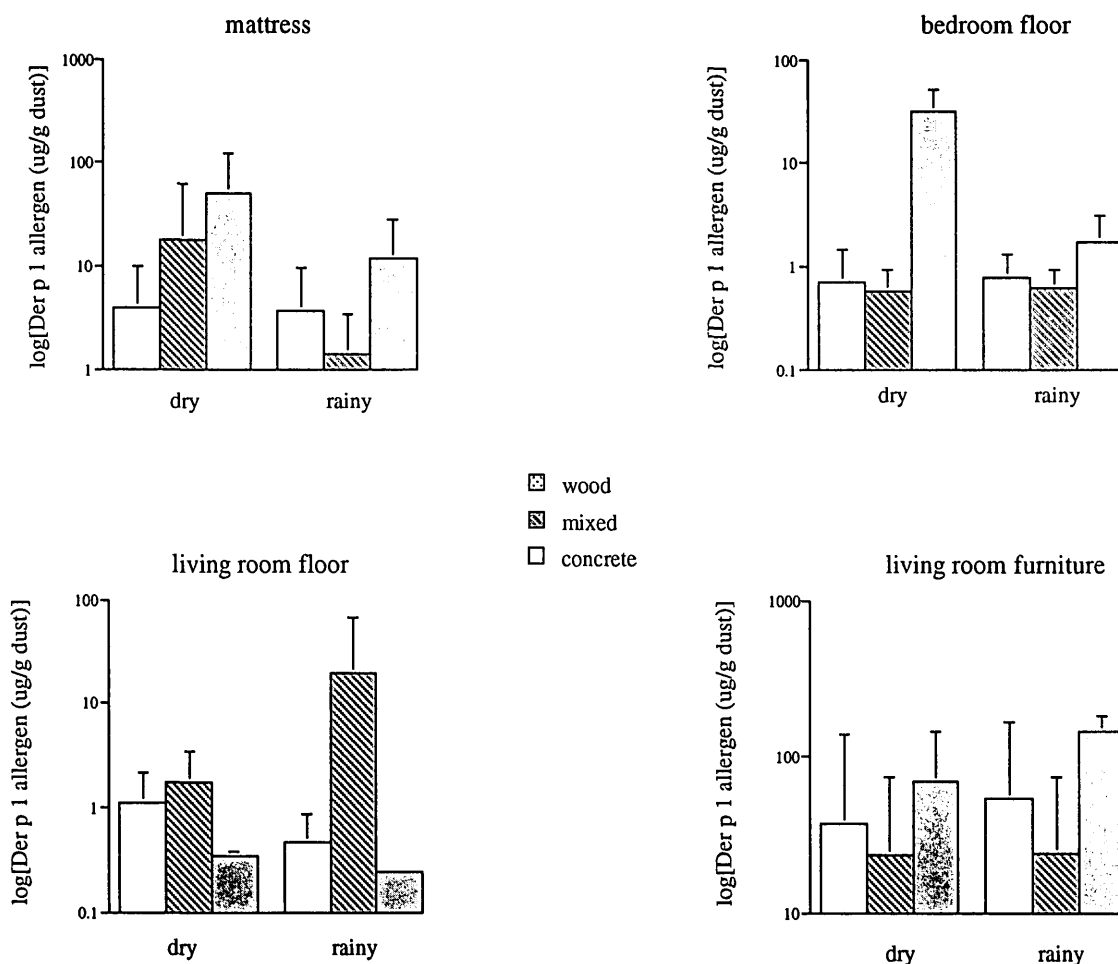


Fig. 1. Geometric mean allergen levels of Der p 1 ($\mu\text{g/g}$) from 4 sites (mattress, bedroom floor, living room floor, living room furniture) during dry and rainy seasons in 17 homes. Mean levels are illustrated in log ($\mu\text{g/g}$) to reduce skewness.

Two- and 3-way interactions (season, location in the home, and the presence of concrete) were not significant; consequently, a main effects ANOVA was conducted on the Der p 1 data. Similar to our findings using a GLM with means for season separated by the Tukey test, Der p 1 concentrations did not vary from the dry to rainy season ($F = 0.03$; $df = 1, 6$; $P > 0.10$). Allergen levels did vary according to location within the home ($F = 3.04$; $df = 3, 6$; $P = 0.03$). An investigation using least-squares means, a GLM ranked procedure, revealed a significant difference among furniture (the location with the highest mean concentration) and the 3 other locations; the pair-wise *t*-test showed significant differences between the bedroom ($P = 0.009$), living room floor ($P = 0.01$), and the mattress, but only at the 0.10 level ($P = 0.07$). Similar associations between site and levels of Der f 1 allergens were not found.

Concrete homes had higher levels of Der p 1 allergens in 3 of the 4 locations than did wood or mixed (wood and concrete) homes ($F = 9.55$; $df = 2, 6$; $P = 0.0001$; Fig. 1). When using the least squares means GLM ranked procedure with house type (wood, mixed, and concrete) as the independent variable, there was a significant difference between wood and concrete homes ($P = 0.0001$) and mixed and concrete homes ($P = 0.0005$), although the difference between wood and mixed homes was not significant. A main-effects ANOVA indicated that mean levels of Der f 1 actually were highest in the wood and lowest in mixed homes; however, the low counts of Der f 1 in addition to a small sample size possibly rendered any observable associations spurious.

Levels of Der p 1 allergen in the mattress were 15.8 ± 37.4 (mean $\pm$ SE) $\mu\text{g/g}$ dust during the dry season and 3.7 ± 6.8 $\mu\text{g/g}$ dust during the rainy season (differences not significant; Table 1). Levels in the mattress were correlated with levels on the bedroom floor during the rainy season ($r = 0.83$, $P = 0.0005$), but not during the dry season ($r = 0.12$, $P = 0.66$). Concentrations increased with the age of the home in both the dry ($r = 0.69$, $P = 0.003$) and rainy season ($r = 0.62$, $P = 0.02$), but were not correlated with any other variables, including homes with more bedrooms, the number of beds in a bedroom, the age of the mattress, the presence of carpet, and household density.

Levels of Der p 1 allergen on the most frequently used piece of living room furniture were 40.4 ± 78.2 $\mu\text{g/g}$ dust (range, 0.02–284) during the dry season and 64.2 ± 90.4 $\mu\text{g/g}$ dust (range, 0.15–252) during the rainy season. Similar to the mattresses, these differences were not significant when tested by the GLM procedure. Allergen levels were not correlated with features of the immediate environment, including age of the piece of furniture, the presence of carpet in the living room, and age of the house. Levels of Der p 1 on the piece of furniture were elevated significantly in homes with higher household densities (number of residents)

during the rainy but not the dry season ($r = 0.62$, $P = 0.02$; $r = 0.29$, $P = 0.27$, respectively). Allergen levels of Der f 1 in both the bedroom mattress and living room furniture were not correlated with any of the variables mentioned above.

Discussion

Our hypothesis that the use of concrete in house construction influences the distribution of house dust mite allergen concentrations is supported by this study. Findings from the main-effects ANOVA association between concrete homes and higher levels of Der p 1 allergens in all 4 locations of the home should be viewed with caution, because there were only 2 homes built entirely of concrete in our study of 17 homes. However, a separate analysis using least-square means, which is a GLM ranked procedure, supported the overall findings; allergen concentrations were significantly higher in concrete homes than in both wood homes and mixed wood and concrete homes.

Der p 1 allergen concentrations were not significantly different between wood and mixed homes, although the least-squares means was higher in the mixed homes than in the homes built entirely of wood, indicating that there was a trend in the increase of allergen concentrations with the introduction of concrete. For the 7 homes classified as mixed, the main area of the home for which concrete was present was the toilet–shower. Only 1 of the mixed homes had a concrete bedroom, and none of the homes had a concrete living room. This is reflective of home improvement patterns in Barbados in general (Barnes 1992), whereby concrete is added first to areas of the home in which indoor plumbing is introduced (e.g., bathroom, kitchen), and eventually all of the wood construction is replaced with concrete. It is possible that the presence of concrete in areas of the home separate from those in which allergen samples were collected (e.g., bathroom) would not have a significant effect on the allergen concentrations in areas of the home constructed of wood (e.g., bedroom mattresses and living room furniture). Only after homes are constructed of or converted to concrete exclusively substantial differences in allergen concentrations deviate from the traditional, all-wood homes.

We speculate that construction with concrete is an important element in the abundance of certain house dust mite species because of the overall accumulation of moisture associated with concrete in housing. Accumulation may be caused by structural factors such as the absence or improper use of moisture barriers, resulting in the wicking of ground moisture, finished ceilings serving as moisture barriers that retain interior moisture, and smaller and fewer windows situated in the moisture-laden areas of the home (e.g., shower stall). Individual contributors of moisture (e.g., indoor shower, number of water taps) did not affect aller-

gen levels according to our analyses. We contend that the small number of homes ($n = 14$ for both seasons) limited the number of independent variables that could demonstrate a relationship at a significant level. Alternatively, the combination of very high relative humidity levels typical of the rainy season plus a home built entirely of concrete may supersede the importance of specific features such as an indoor shower or toilet.

The finding that *Dermatophagoides* allergens are common in Barbadian homes is concordant with that of Pearson and Cunningham (1973) 2 decades ago. The extremely low concentration of *D. farinae* allergens (and in some cases, absence of the species altogether) is also consistent with that study. In other studies, populations of *D. farinae* were remarkably lower than *D. pteronyssinus* when both species were found in the same locale (Charlet et al. 1978, Chang and Hsieh 1989), or, alternatively, when *D. farinae* is absent and *D. pteronyssinus* is present (Colloff 1987, 1988). The mean concentration of Der p 1 allergen ranging from 3.7 to 15.8 $\mu\text{g/g}$ of dust in mattresses and 40.4 to 64.2 $\mu\text{g/g}$ in living room furniture are well above the 2 $\mu\text{g/g}$ "at risk" level reported by Platts-Mills and de Weck (1989).

Levels of both Der p 1 and Der f 1 did not change significantly from the dry to rainy season, contrary to previous studies (Charlet et al. 1978; Colloff 1988, 1991). The temporal abundance of house dust mites typically is dependent on relative humidity and usually peak during the warmest and wettest months (Wharton 1976, Charlet et al. 1978). In Barbados, relative humidity ranges from a low of 73% (January) to a high of 85% (November), and temperature ranges from a low of 21 to a high of 28.5°C, providing an ideal year-round environment for house dust mites. Concrete, plumbing, and other modern features have been incriminated in increasing indoor relative humidity and reducing air flow (Hansen 1984, Arundel et al. 1986), 2 factors that create favorable habitats for the house dust mite (Murray and Zuk 1979, Korsgaard and Iversen 1991). Air conditioning, a modern feature which reduces house dust mite populations by lowering humidity (Lintner and Brame 1993) is not a feature of home improvement in Barbados, and, if available at all, is present only in businesses and tourist-related facilities (e.g., hotels, restaurants).

Studies in both temperate and tropical regions have demonstrated that mite populations can vary substantially from month to month and peak in different months from one year to the next (Murray and Zuk 1979, Arlian et al. 1982, Chang and Hsieh 1989). Furthermore, monthly variations cannot be attributed to outdoor temperature or relative humidity alone. Because house dust mite samples only were collected at 2 time points in our study, fluctuations in allergen concentrations from the Barbadian homes may have been missed. However, high levels of the major allergen from *D. pter-*

onyssinus were detected in mattresses and especially in living room furniture in both seasons, indicating the presence of high levels of allergen year-round. Seasonal fluctuation in this setting, therefore, may be of little clinical relevance.

Although house dust mites thrive where there is the presence of irregular surfaces that trap dust and skin scales, the bedroom (particularly the mattress) is thought to be the primary focus (Wharton 1976, Hallas 1991, Korsgaard and Iversen 1991). However, in Barbados, levels were higher in living room furniture than in the mattress or bedroom, agreeing with previous research (Arlian et al. 1982, Feldman-Muhsam et al. 1985). One argument put forth as an explanation for allergen levels being higher in furniture than in mattresses is that bedclothing is washed regularly, whereas upholstered furniture is cleaned rarely. Unfortunately, in our study, these data were not available. The effect of season was evident in that homes with greater household densities had higher levels of Der p 1 in their living room furniture during the rainy season, indicating that more time is spent in this part of the house during the rainy season or the intensified presence of residents during the rainy season further contributes to the proliferation of *D. pteronyssinus* in this microhabitat.

Barbados offers a unique opportunity to examine the role of modernization on the spatial and temporal distribution of *Dermatophagoides* spp. within the domestic environment, because of the rapid infrastructural transformation in that country over the past few decades. In this tropical setting, levels of Der p 1 and Der f 1 were not affected by season in general. *D. pteronyssinus* is a ubiquitous allergen in the domestic environment; *D. farinae* is of much less importance. The data indicates that concrete housing provides a more favorable habitat for *D. pteronyssinus* than wood housing. Because construction of concrete homes in Barbados is on the increase, exposure to *D. pteronyssinus* will affect progressively Barbadians and likely will contribute to allergic disease in that country.

Acknowledgments

We thank Jeffrey Jones and the staff at the Ministry of Agriculture, Entomology Section, Graeme Hall, Barbados, for technical support; Chris Everard, formally of the Leptospira Laboratory, Medical Research Council, Barbados, for providing storage of the samples; and Cindy Hewitt for assisting in the statistical analysis. This work was supported in part by USDA-ARS.

References Cited

- Anonymous 1994. 1990. population and housing census. Barbados, vol. 1, May 1, 1990. Bridgetown, Barbados.
- Arlian, L. G., I. L. Bernstein, and J. S. Gallagher. 1982. The prevalence of house dust mites, *Dermatophagoides* spp. and associated environmental con-

- ditions in homes in Ohio. *J. Allergy Clin. Immunol.* 69: 527-532.
- Arundel, A. V., E. M. Sterling, J. H. Biggin, and T. D. Sterling. 1986. Indirect health effects of relative humidity in indoor environments. *Environ. Health Perspect.* 65: 351-361.
- Barnes, K. C. 1992. The role of household pests in the epidemiological transition of allergy: modernization of the domestic environment in Barbados. Ph.D. dissertation, University of Florida, Gainesville.
- Buchanan, D. J., and I. G. Jones. 1972. Allergy to house-dust mites in the tropics. *Br. Med. J.* 21: 764.
- Chang, Y., and K. Hsieh. 1989. The study of house dust mites in Taiwan. *Ann. Allergy* 62: 101-106.
- Chapman M. D., and T.A.E. Platts-Mills. 1980. Purification and characterization of the major allergen from *Dermatophagoides pteronyssinus* antigen P1. *J. Immunol.* 125: 587-592.
- Chapman, M. D., P. W. Heymann, S. R. Wilkins, M. J. Brown, and T.A.E. Platts-Mills. 1987. Monoclonal immunoassay for major dust mite (*Dermatophagoides*) allergens content of mite and house dust extracts. *J. Allergy Clin. Immunol.* 80: 184-194.
- Charlet, L. D., M. S. Mulla, and M. Sanchez-Medina. 1978. Domestic Acari of Colombia: population trends of house dust mites (Acari: Pyroglyphidae) in homes in Bogota, Colombia. *Int. J. Acarol.* 4: 23-31.
- Colloff, M. J. 1987. Mites from house dust in Glasgow. *Med. Vet. Entomol.* 1: 163-168.
1988. Mite ecology and microclimate in my bed, pp. 51-54. In A. L. DeWeck and A. Todt [eds.], *Mite allergy, a world-wide problem*. UCB Institute of Allergy, Brussels.
1991. Practical and theoretical aspects of the ecology of house dust mites (Acari: Pyroglyphidae) in relation to the study of mite-mediated allergy. *Rev. Med. Vet. Entomol.* 79: 611-630.
- Conover, W. J., and R. L. Iman. 1981. Rank transformations as a bridge between parametric and non-parametric statistics. *Am. Stat.* 35: 124-129.
- Dann, G. 1984. The quality of life in Barbados. MacMillan, London.
- Dowse, G. K., K. J. Turner, G. A. Stewart, M. P. Alpers, and A. J. Woolcock. 1985. The association between *Dermatophagoides* mites and the increasing prevalence of asthma in village communities within the Papua New Guinea highlands. *J. Allergy Clin. Immunol.* 75: 75-83.
- Feldman-Muhsam, B., Y. Mumcuoglu, and T. Osterovich. 1985. A survey of house dust mites (Acari: Pyroglyphidae and Cheyletidae) in Israel. *J. Med. Entomol.* 22: 663-669.
- Fernandez-Caldas, E., L. Puerta, D. Mercado, R. F. Lockey, and L. R. Caraballo. 1993. Mite fauna, Der p 1, Der f 1 and *Blomia tropicalis* allergens in a tropical environment. *Clin. Exp. Allergy* 23: 292-297.
- Hallas, T. E. 1991. The biology of mites. *Allergy* 46: 6-9 (suppl. 11).
- Hansen, A. T. 1984. Moisture problems in houses. Division of Building Research, Canadian Building Digest, 231.
- Holck, A., S. Dale, and K. Sletten. 1986. Purification and characterization of a major allergen from the house dust mite *Dermatophagoides farinae*. *Allergy* 41: 408-417.
- Korsgaard, J., and M. Iversen. 1991. Epidemiology of house dust mite allergy. *Allergy* 46: 14-18.
- Lau, S., G. Falkenhorst, A. Weber, I. Werthmann, P. Lind, P. Buettner-Goetz, and U. Wahn. 1989. High mite-allergen exposure increases the risk of sensitization in atopic children and young adults. *J. Allergy Clin. Immunol.* 84: 718-725.
- Lind, P. 1985. Purification and partial characterization of two major allergens from the house dust mite, *Dermatophagoides pteronyssinus*. *J. Allergy Clin. Immunol.* 76: 753-761.
- Lintner, T. J., and Brame, K. A. 1993. The effects of season, climate, and air-conditioning on the prevalence of *Dermatophagoides* mite allergens in household dust. *J. Allergy Clin. Immunol.* 91: 862-867.
- Lowenthal, D. 1957. The population of Barbados. *Soc. Econ. Stud.* 6: 445-501.
- Massicot, J. G., and S. G. Cohen. 1986. Epidemiologic and socioeconomic aspects of allergic diseases. *J. Allergy Clin. Immunol.* 78: 954-958.
- Murray, A. B., and P. Zuk. 1979. The seasonal variation in a population of house dust mites in a North American city. *J. Allergy Clin. Immunol.* 64: 266-269.
- Pearson, R.S.B., and A. M. Cunningham. 1973. The importance of mites in house dust sensitivity in Barbadian asthmatics. *Clin. Allergy* 3: 299-306.
- Platts-Mills, T.A.E., and A. L. de Weck. 1989. Dust mite allergens and asthma—a worldwide problem. *J. Allergy Clin. Immunol.* 83: 416-427.
- Platts-Mills, T.A.E., M. L. Hayden, M. D. Chapman, and S. R. Wilkins. 1987. Seasonal variation in dust mite and grass-pollen allergens in dust from the houses of patients with asthma. *J. Allergy Clin. Immunol.* 79: 781-791.
- Platts-Mills, T.A.E., W. R. Thomas, R. C. Aalberse, D. Vervloet, and M. D. Chapman. 1992. Dust mite allergens and asthma: report of a second international workshop. *J. Allergy Clin. Immunol.* 89: 1046-1060.
- Pollart S. M., M. D. Chapman, G. P. Fiocco, G. Rose, and T.A.E. Platts Mills. 1989. Epidemiology of acute asthma: IgE antibodies to common inhalant allergens as a risk factor for emergency room visits. *J. Allergy Clin. Immunol.* 83: 875-882.
- Potter, R. B. 1986. Housing upgrading in Barbados: the tenancies programme. *Geography* 71: 255-257.
- SAS Institute. 1988. SAS/STAT guide for personal computers, version 6.4 ed. SAS Institute, Cary, NC.
- Searle, S. R., F. M. Speed, and G. A. Milliken. 1980. Populations marginal means in the linear model: An alternative to least squares means. *Am. Stat.* 34: 216-221.
- Sporik, R., S. T. Holgate, T.A.E. Platts-Mills, and J. J. Cogswell. 1990. Exposure to house-dust mite allergen (Der p 1) and the development of asthma in childhood—a prospective study. *N. Engl. J. Med.* 323: 502-507.
- Swanson, M. C., A. R. Campbell, J. Klauck, and C. E. Reed. 1989. Correlation between levels of mite and cat allergens in settled and airborne dust. *J. Allergy Clin. Immunol.* 83: 776-783.
- Symantec Corp. 1991. Q&A database, version 4.0 ed. Symantec, Cupertino, CA.
- Tovey, E. R., M. D. Chapman, C. W. Wells, and T.A.E. Platts-Mills. 1981. The distribution of house dust mite allergen in the houses of patients with asthma. *Am. Rev. Respir. Dis.* 124: 630-635.
- van Bronswijk, J.E.M.H. 1973. *Dermatophagoides pteronyssinus* (Troussart 1897) in mattress and floor

- dust in a temperate climate. (Acari: Pyroglyphidae). J. Med. Entomol. 10: 63–70.
- Vervloet, D., D. Charpin, E. Haddi, A. N'guyen, J. Birnbaum, M. Soler, and X. van der Brempt. 1991.** Medication requirements and house dust mite exposure in mite sensitive asthmatics. Allergy 46: 554–558.
- Wharton, G. W. 1976.** House dust mites. J. Med. Entomol. 12: 577–621.
- Received for publication 9 February 1995; accepted 26 September 1996.*
-