

Dust-mite-allergen concentrations in asthmatics' bedrooms in the Quad Cities (Illinois, USA) after the Mississippi River floods of 1993

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**L. Curtis, M. Ross, P. Scheff,
V. Persky, R. Wadden,
V. Ramakrishnan, D. Hryhorczuk**

School of Public Health at University of Illinois at Chicago, IL; Departments of Environmental and Occupational Health Science, Biostatistics and Epidemiology, Chicago, IL, USA

This study aimed to measure allergens from *Dermatophagoides farinae* and *D. pteronyssinus* and to examine possible relationships of these mite allergens with flooding and other housing factors. A total of 313 dust samples were collected from the bedrooms of 57 asthmatics in 45 homes in the Quad Cities (Illinois, USA) and analyzed by ELISA for the presence of the *D. farinae* and *D. pteronyssinus* allergens. Twenty of these homes had some flooding in the last 12 months due to the Mississippi River floods of 1993 and/or other factors. The log-transformed least-squares means of allergens collected were 28 ng/m² for the *D. farinae* allergen and 26 ng/m² for the *D. pteronyssinus* allergen. *D. farinae* allergen levels were significantly higher in homes located in the valley, in homes during the summer months, in homes with furred or feathered pets, in homes which had not been flooded in the last year, and in homes where rugs had been steam-cleaned in the last 12 months. *D. pteronyssinus* allergen levels were significantly higher in homes located in the valley, in homes during April and July-September, in homes with furred or feathered pets, and in homes with no dehumidifier.

Key words: *Dermatophagoides farinae*; *Dermatophagoides pteronyssinus*; dust mites; flooding; pets.

Luke Curtis
School of Public Health West
2121 West Taylor Street
Chicago
IL 60612
USA

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Dermatophagoides farinae, *D. pteronyssinus*, and other *Dermatophagoides* species comprise most of the mites present in homes (1). These mites are about 500 µm long, eat mostly skin and hair of man and mammalian and avian pets, and secrete highly allergenic droppings (1, 2). Indoors, mite allergens are present in greatest concentrations in mattresses, pillows, and beds as well as in other parts of the home where skin and hair fragments are present (2, 3).

A number of studies have examined the relationship of housing factors and mite-allergen concentrations in house dust. Chan-Yeung et al. (4) noted higher concentrations of *D. farinae* and *D. pteronyssinus* allergens in the more humid environment of Vancouver, Canada, than in the drier climate of Winnipeg, Canada. De Andrade et al. (5) noted much higher concentrations of the *D. farinae* and *D. pteronyssinus* allergens in humid

Casablanca, Morocco, than in the drier city of Marrakech, Morocco. Dehumidifiers significantly reduced *D. pteronyssinus* allergen concentrations in Canary Islands homes (6). However, a study in the UK reported that the use of a single portable dehumidifier placed centrally in homes did not significantly lower *D. pteronyssinus* allergen levels (7). Some studies have noted a considerable increase in dust-mite concentrations during the warmer and wetter summer and autumn months (8, 9), while other studies have noted that seasonal changes in dust-mite concentrations are quite modest (4, 10). Lintner & Brame (8) noted that *D. farinae* allergens tended to predominate in air-conditioned homes, while *D. pteronyssinus* allergens tended to predominate in homes not air-conditioned.

Kuehr et al.'s (11) study of the homes of 1291 German schoolchildren found the following factors

associated with higher concentrations of *D. farinae* allergens: mattress older than 2 years, woods or fields in vicinity of the home, and high educational level of parents. Factors associated with higher *D. pteronyssinus* concentrations included lower level of bunk beds, wet spots in bedroom, basement bedrooms, and woods or fields in vicinity. Wickman et al. (12) noted lower dust-mite concentrations in mechanically ventilated than naturally ventilated homes.

This study examined the relationship among flooding, housing factors, and *D. farinae* and *D. pteronyssinus* concentrations in areas of the Quad Cities, Illinois, USA, which were significantly flooded.

Material and methods

Sample design and recruitment

This study measured total dust levels and concentrations of the *D. farinae* and *D. pteronyssinus* allergens in bedroom dust. Sampling was conducted from April to October 1994 in Rock Island and Henry counties, Illinois. Forty-five homes of 57 asthmatics were selected from a health questionnaire administered at United Township High School (East Moline, Illinois) and by telephone solicitation of residents in the flooded areas. Ten of these homes were located in low-lying areas on Campbells Island or in Hampton which were flooded during the Mississippi River floods of 1993. Ten more homes were located in the Mississippi or Rock River valleys but were more than 200 m from the river and were not flooded. Eight more homes were located on hillsides facing one of these rivers and 17 homes were located on a hilltop plateau about 20–30 m above the level of the river. A total of 20 homes had some water in the basement over the last 12 months due to either river flooding or other causes.

Detailed questionnaire interviews were conducted to determine the extent of the 1993 flood, housing conditions, details of other family members, number and type of pets present, chemical usage, health status, and other factors. A total of 265 visits and 313 dust-mite samplings were made at approximately 3-week intervals for a 4–7-month period in each of the homes. During each visit, outdoor and indoor temperature and humidity were determined with a sling psychrometer. Household activities, odors, and outdoor weather conditions were also recorded during each sampling visit. Most of the patients recorded humidity and temperature twice daily with a Taylor humidity gauge. Patient-recorded indoor temperature and humidity records were available for 229 of the 313 dust samples.

Dust collection

Dust was collected with a Sears Kenmore 2.0 vacuum cleaner using a clean cotton filter inside a plastic dust trap attached to the vacuum tube. Each dust sample was a pooled sample of 1 min of vacuuming of a 1 m² area on the bedding and 1 min of vacuuming of 1 m² of the floor next to the bed. Dust was placed in plastic bags and frozen for further analysis.

ELISA analysis of dust

The dust was then screened with a 650-µm filter and weighed out to the nearest milligram on an analytic balance. The samples were then analyzed for *D. farinae* (Dep f 1) and *D. pteronyssinus* (Der p 1) allergens with the sandwich-ELISA method of Chapman et al. (13). Monoclonal antibodies and standard allergens were purchased from Lisa Vailes of the University of Virginia (Charlottesville, VA, USA), and all other chemicals were purchased from Sigma (St Louis, MO, USA) and were reagent grade or better. Standard allergen-dilution curves and blanks were run during each day of dust-mite ELISA. For each sample, *D. farinae* and *D. pteronyssinus* allergen concentrations were then calculated by interpolation of the standard allergen-absorbance curves. For all dust samples, the total amount of dust collected in the 2-min sample was recorded, and both the total mass (ng/m² sampled) and concentrations (ng allergen/mg dust or µg/g or PPM) of both dust-mite allergens were calculated. Note that, in a few cases, the total mass of allergen collected was slightly negative because of sample variation and variations in the ELISA.

Statistical considerations

Means for allergen concentrations and total mass collected per sample were calculated under various housing conditions (such as flooding conditions, presence of pets, etc.). Data were highly skewed, with a few very high values; therefore, natural log-transformed analysis of the allergen levels was used. Significant differences were determined with a two-way ANOVA on the natural log of allergen concentrations, the SAS statistical program being used to control for home-to-home variability. The log-transformed data were used, since the variables in the original, untransformed units were non-normally distributed. In Table 2, the means presented for various condition levels are from this model, the least-squares means being used and adjusted for the home sampled. Thus, the 95% confidence levels presented are asymmetric. All values listed in Table 2 refer to home natural

log-transformed least-squares means, and not individual samples.

Results

Weather data are summarized in Table 1. Table 1 notes that May was a very dry month. Note that from June to September, in homes with air conditioning in operation, the mean temperature was 23.0°C indoors and 26.3°C outdoors, and the mean relative humidity was 53.1% indoors and 66.2% outdoors. From June through September, in homes with no air conditioning, the mean temperature was 23.3°C indoors and 24.6°C outdoors, and the mean relative humidity was 58.6% indoors and 64.3% outdoors.

The mean bedroom allergen concentrations were 139 ng/m³ for the *D. farinae* allergen and 103 ng/m³ for the *D. pteronyssinus* allergen. One-way ANOVA analysis found significant between-home differences for mite-allergen levels (P of 0.0000 for *D. farinae* collected and P of 0.0000 for *D. pteronyssinus*).

Table 2 notes overall natural log-transformed least-squares means for all 313 samples, adjusted for home averages. Table 2 also shows log-transformed least-squares means of allergen levels collected under the various flooding and housing conditions. In Table 2, the effects of individual homes are controlled for, and the sample size reported is the number of homes per group. The homes are used as a weighting factor in this least-square means analysis, and the total sample size listed is the number of homes. The extreme ranges for all of the individual 313 samples, not adjusted for home averages, are -18 to 9314 ng/m² of *D. farinae* allergen and -17 to 3299 ng/m² of *D. pteronyssinus* allergen.

Table 2 shows that mean *D. farinae* levels were significantly higher in valley homes, in homes during summer months, in homes with furred or feathered pets, and in homes where rugs were steam-cleaned in the last 12 months. Least-squares mean *D. farinae* concentrations were almost four times as high (41.6 vs 11.9 ng) in homes with pets ($P=0.0001$). Note that maximum home mean *D. farinae*-allergen levels collected were 792 ng in homes with pets and only 104 ng in homes without pets. (For individual samples, the maximum *D. farinae* concentrations were 9314 in homes with pets and 407 in homes without pets.) *D. farinae*-allergen concentrations were not significantly affected by the presence of air conditioners or dehumidifiers, or home reconstruction. *D. farinae*-allergen concentrations were significantly higher in bedrooms of unflooded homes than flooded homes. However, when only basement bedrooms were considered, *D. farinae*-allergen concentrations

Table 1. Summary of weather conditions

Month	Mean daily high °C	Mean daily low °C	Mean noon relative humidity %	Mean midnight relative humidity %	Total monthly rainfall (cm)	Mean wind speed (km/h)	% Sunshine	Mean indoor relative humidity %	Mean indoor temperature °C
March	10.1	-2.0	54	74	1.62	14.88	64	N/A	N/A
April	16.1	4.3	45	62	6.71	17.60	53	40.3	22.7
May	23.9	8.1	42	77	4.24	9.80	79	43.8	23.1
June	29.5	15.9	63	86	12.26	9.76	76	47.7	24.6
July	28.5	16.8	63	88	14.45	9.76	76	50.6	24.7
August	27.2	15.3	67	88	8.64	9.44	88	51.4	24.4
September	25.2	12.6	57	86	3.89	8.80	66	50.3	23.2
October	19.2	7.1	53	77	4.24	11.20	43	50.9	21.6

Weather data from Quesd Cities Airport and indoor data from patient temperature and humidity logs. Last spring frost on 30 April and first autumn frost on 10 October.

Table 2. Summary of dust-mite allergens collected

Condition	No. of homes	<i>D. farinae</i> allergen ng/m ²				<i>D. pteronyssinus</i> allergen ng/m ²			
		Mean	95% Confidence interval for mean	Median	Range	Mean	95% Confidence interval for mean	Median	Range
Overall	45	27.6	19.1–37.9	14.8	–3.9 to 792.4	25.6	17.5–35.5	15.9	–2.7 to 201.4
Geographic location of home		$P=0.0014^*$				$P=0.0117^*$			
Riverside	10	16.9	9.9–25.4	13.4	–3.9 to 270.0	22.4	14.4–32.1	22.1	2.6–131.4
Valley	10	54.7	35.6–80.2	11.8	–3.2 to 313.6	47.6	30.4–70.5	28.9	3.8–178.3
Hillside	8	39.2	20.8–65.7	25.6	1.5–625.5	19.4	7.3–40.0	14.8	–2.7 to 201.4
Hilltop	17	29.0	22.1–37.7	14.5	15.9–792.4	18.6	13.0–25.1	12.5	3.6–15.5
By month ^b		$P=0.0003$				$P=0.0014$			
April	8	10.2	–1.9 to 30.4	0.3	–16.5 to 23.4	33.0	11.8–68.7	15.8	–1.1 to 1065.7
May	14	5.0	–4.2 to 19.7	–1.6	–9.1 to 383.4	20.4	5.4–44.3	14.8	–5.8 to 253.1
June	31	15.1	7.1–25.3	6.8	–14.6 to 776.3	6.08	1.5–16.0	3.8	–3.2 to 84.6
July	39	48.0	34.6–64.4	26.1	–0.5 to 2080.8	27.4	18.0–39.0	17.3	–10.2 to 1132.9
August	40	35.1	24.4–48.6	22.9	–0.9 to 1346.5	27.6	18.2–39.3	10.9	–1.5 to 1023.1
September	38	36.0	24.5–50.3	17.3	–1.5 to 1978.2	42.1	29.3–58.4	14.8	–2.0 to 3177.1
October	36	34.7	22.2–51.0	13.1	–3.6 to 9300.8	22.4	12.6–35.2	9.1	–1.1 to 430.3
Story of bedroom ^c		$P=0.656$				$P=0.865$			
Basement	11	42.8	16.3–88.5	21.3	–3.2 to 145.6	26.6	7.0–60.4	25.2	5.0–330.7
First floor	24	23.2	8.5–41.8	17.0	–3.9 to 270.0	21.0	7.9–40.3	12.5	–2.7 to 178.3
Second floor	17	36.5	17.0–66.3	15.9	–2.4 to 792.4	29.7	12.5–55.9	12.8	–0.3 to 300.5
Furred or feathered pets present?		$P=0.0001$				$P=0.0157$			
Yes	29	41.6	33.5–50.9	24.7	–3.2 to 792.4	29.4	22.9–36.8	19.6	–2.7–178.3
No	16	11.9	6.0–19.3	10.6	–3.9 to 104.0	16.1	9.3–24.5	8.8	–0.3 to 201.4
Air conditioning (AC) in use?		$P=0.662$				$P=0.679$			
AC in use	26	35.1	23.0–50.7	9.4	–9.8 to 2080.6	19.8	10.3–32.4	10.0	–1.8 to 93.3
June–September	42	27.9	21.4–35.5	22.9	–3.7 to 467.9	25.8	19.0–33.8	18.5	–8.4 to 776.3
AC not in use									
June–September									
Home flooded last year (all bedrooms)?		$P=0.008$				$P=0.111$			
No	25	37.1	28.8–46.8	25.2	–3.2 to 792.4	28.4	21.4–36.6	17.3	2.6–178.3
Yes	20	21.4	17.8–25.3	11.5	–3.8 to 313.6	19.9	16.5–23.7	14.9	–2.7 to 201.4
Home flooded last year (basement bedrooms only)		$P=0.240$				$P=0.392$			
No	5	17.9	3.1–42.2	4.0	–3.2 to 145.7	20.5	3.2–50.9	21.7	5.0–111.6
Yes	6	23.8	16.0–33.3	23.8	4.0–87.8	54.8	41.5–71.0	28.5	7.9–247.7

were nonsignificantly higher in the flooded homes. *D. farinae*-allergen mass was nonsignificantly higher in basement bedrooms than first-floor bedrooms.

Table 2 shows that mean *D. pteronyssinus*-allergen levels were significantly higher in valley homes, in homes during the months of April and July–September, in homes with furred or feathered pets, and in homes without a dehumidifier. *D. pteronyssinus*-allergen levels were not significantly affected by air conditioning, home reconstruction,

or steam-cleaning of rugs in the past 12 months. Considering only basement bedrooms, *D. pteronyssinus*-allergen levels were nonsignificantly higher in flooded homes. However, when all bedrooms on all floors were considered, the *D. pteronyssinus*-allergen levels were nonsignificantly higher in unflooded homes. *D. pteronyssinus*-allergen levels were somewhat higher in basement and second-floor bedrooms than in first-floor bedrooms, but this difference was not statistically significant.

Table 2. Cont. Summary of dust-mite allergens collected

Condition	No. of homes	<i>D. farinae</i> allergen ng/m ²				<i>D. pteronyssinus</i> allergen ng/m ²			
		Mean	95% Confidence interval for mean	Median	Range	Mean	95% Confidence interval for mean	Median	Range
Home reconstructed in last 12 months?			<i>P</i> =0.412				<i>P</i> =0.529		
Yes	8	40.4	20.9–54.5	35.1	3.6–270.0	20.8	10.3–19.9	20.0	6.0–39.1
No	37	27.3	21.8–33.8	13.8	–3.9 to 792.4	25.3	19.9–31.4	15.9	–2.7 to 201.4
Dehumidifier in home?			<i>P</i> =0.841				<i>P</i> =0.0001		
Yes	14	28.6	18.8–40.9	8.2	–3.2 to 792.4	11.4	5.1–19.3	7.1	–0.3 to 35.1
No	31	29.9	23.6–37.2	19.6	–3.9 to 625.4	32.9	26.2–40.6	23.4	–2.7 to 201.4
Rugs steam-cleaned in past 12 months?			<i>P</i> =0.0083				<i>P</i> =0.542		
Yes	18	39.6	30.9–49.6	17.3	–3.9 to 792.4	22.6	16.4–29.8	14.1	2.6–201.4
No	27	23.7	17.1–31.6	14.8	–3.4 to 313.6	25.7	18.8–33.9	18.9	–2.7 to 154.2

* *P* values listed are overall group significance of nonhome factor in two-way ANOVA.

† All 45 homes were not sampled every month.

‡ Some homes had asthmatic bedrooms on more than one floor – hence, 52 samples even though there were only 45 homes.

Table 2 notes that *D. farinae* levels were very low during the dry month of May. Little relationship was noted between indoor humidity at sampling time and mass of dust-mite allergens (data not shown). Little relationship was also noted between average monthly indoor humidity and average mass of collection of *D. farinae* and *D. pteronyssinus* allergens (*r* of only 0.146 for *D. farinae* allergens and 0.082 for *D. pteronyssinus* allergens).

Chi-square analysis of the various housing factors listed in Table 2 (data not shown) found a significant correlation between pets in the home and levels of flooding. (Only 10/20 flooded homes [50%] had pets as opposed to 20/25 [80%] of the unflooded homes – Pearson *P* of 0.033.) Since presence of pets was associated with significantly increased levels of both dust-mite allergens, it was decided to include presence of pets in the home along with homes and flooding in a three-way ANOVA model. In this way, the effects of flooding could be estimated while taking into account the presence of pets in the homes. When the effect of pets and homes was taken into account, flooding did not have a significant effect on levels of either the *D. farinae* (*P*=0.515) or the *D. pteronyssinus* (*P*=0.824) allergen.

Table 2 notes significantly different allergen levels in homes located in different geographic locations in the sampling area. The riverside homes had significantly lower allergen levels than homes located in other areas. Only 5/10 of the riverside

homes contained pets as compared to 25/35 of nonriverside homes (Pearson *P*=0.20). In a three-way ANOVA model taking into account the effects of homes, pets, and geographic location of the homes, the riverside homes still had significantly lower mite-allergen levels (*P*=0.0051 for *D. farinae* and *P*=0.0099 for *D. pteronyssinus*) than homes located in other areas.

Detailed analysis was also made to compare the house-dust concentrations (µg/g) of the *D. farinae* and *D. pteronyssinus* allergens with various flooding and housing factors described in Table 2. In general, this analysis did not differ significantly from the Table 2 analysis (data not shown). For the *D. farinae* allergen, the mean, median, natural log-transformed mean, natural log-transformed standard error, and range of concentrations for all samples were 1.15, 0.18, 0.51, 0.080, and –0.32 to 62.30 µg/g, respectively. For the *D. pteronyssinus* allergen, the mean, median, natural log-transformed mean, natural log-transformed standard error, and range of concentrations for all samples were 0.72, 0.19, 0.61, 0.090, and –0.10 to 12.14 µg/g, respectively.

Additional regression analysis indicated that average outdoor monthly humidity or rainfall over the 7-month sampling period was not significantly associated with allergen levels (or natural log-transformed allergen levels) of either the *D. farinae* or the *D. pteronyssinus* allergen (data not shown).

In most cases, there was little association between the various flooding and housing factors listed in Table 2 and the total amounts of dust collected in the homes (data not shown). The mean, median, and range of total dust collected per 1 m² bedroom sample were 178, 76, and 1.5–10415 mg, respectively.

A multiple linear regression procedure was used to relate various housing, weather, and sampling factors with the log of *D. farinae* and *D. pteronyssinus* allergens collected (ng/m²). All of the factors were included initially, and factors with a T-significance value greater than 0.10 were eliminated sequentially one-by-one until all remaining factors were significant at a 0.10 level. Housing factors significantly associated with the *D. farinae*-allergen concentrations were as follows: positive associations – indoor relative humidity, outdoor humidity, presence of pets, steam-cleaning of carpets, windows open at sampling time, and musty odor; negative associations – indoor temperature and flooding in the last 12 months. Housing factors significantly associated with the *D. pteronyssinus*-allergen concentrations were as follows: positive associations – windows open at sampling time and outdoor relative humidity; negative associations – dehumidifier use, rain in last 24 h, story of bedroom other than basement, and indoor relative humidity.

Discussion

Table 2 notes that *D. farinae* levels were significantly lower in flooded homes than unflooded homes and that *D. pteronyssinus*-allergen concentrations were nonsignificantly lower in the flooded homes. However, considering basement bedrooms only, *D. farinae* and *D. pteronyssinus* levels were nonsignificantly higher in the flooded homes. We suspect that the flooded homes were cleaned more carefully than other homes, but still had residual moisture in the basement.

Table 2 shows low allergen levels in May for *D. farinae* and low levels for *D. pteronyssinus* in June. May was a fairly dry month with only 4.24 cm of rain (Table 1). Lintner & Brame's year-round study (8) of 536 dust samples from all parts of the USA noted that mean concentrations of total *D. farinae* and *D. pteronyssinus* reached a minimum of 4 µg/g during May and then rose quickly to a maximum of 20 µg/g during July.

Several studies have noted that dust mites and dust-mite allergens are more prevalent in areas of high relative humidity. *Dermatophagoides* spp. growth is greatest at humidities of 70% or more (2), and the mites cannot grow at humidities below about 50% (1). Spiekma et al. (14) reported *D. pteronyssinus* growth to be maximal at about 25°C

and 70–80% relative humidity. Munir et al. (15) noted that higher relative humidities were significantly associated with higher dust concentrations of *D. farinae* and *D. pteronyssinus* allergens in living rooms and bedrooms. Wickman et al. (12) noted that total concentrations of *D. farinae*, *D. pteronyssinus*, and *D. microceras* allergens were significantly higher in homes with absolute humidities exceeding 7 g/kg air. The relatively low mean amounts of dust-mite allergens noted in Table 2 may be related to the fact that patient-recorded indoor humidity averaged only 49.5% (SD 9.3%) (Table 1).

On the other hand, Kalra et al. (10) noted that levels of *D. pteronyssinus* in mattresses and in bedroom and living-room carpets were only slightly higher in the humid month of October 1990 (mean indoor relative humidity of 79%) than in the dry month of April 1991 (mean indoor relative humidity of only 53%).

This study did not demonstrate a major relationship between indoor relative humidities during sampling periods and dust-mite allergens. Dust-mite and dust-mite-allergen concentrations are probably more dependent upon long-term than short-term relative humidities. Dust mites have an average life cycle of 20–26 days from egg to adult and a 60–150-day adult life span (14). Kort & Knies (16) noted that the *D. pteronyssinus* allergen was relatively stable for 47 months under ambient temperatures. The large monthly fluctuations in mite-allergen levels seen in Table 2 suggest that most of the asthmatics cleaned their bedrooms regularly and thus prevented accumulation of mite allergens in the dust.

Table 2 notes relationships between air conditioning and allergen concentrations. Lintner & Brame (8) and Munir et al. (15) noted that *D. farinae* predominates in drier climates, while *D. pteronyssinus* predominates in wetter climates. The nonsignificantly higher *D. farinae* levels and nonsignificantly lower *D. pteronyssinus* levels noted in the summer in air-conditioned homes may be due to the lower humidities recorded there (Table 2). Several studies (8, 17) have noted that *D. farinae* tends to predominate in air-conditioned homes. Again, because of the long-term stability of mite allergens (16), it probably makes more sense to consider long-term air-conditioner use, and not whether the air conditioner is on at a given moment.

Similarly, the significantly lower *D. farinae* concentrations seen in air-conditioned homes may be due to a humidity-lowering effect. The higher *D. farinae*-allergen levels in homes with steam-cleaned carpets suggest that increasing moisture on carpets may play a role in increasing *D. farinae*-allergen levels.

Mean levels of *D. farinae* allergens (Table 2) were nonsignificantly higher on basement bedrooms than other stories of the house, while *D. pteronyssinus*-allergen levels were nonsignificantly higher on the second-floor levels. On the other hand, Kuehr et al. (11) noted that *D. pteronyssinus* concentrations were significantly higher in basement bedrooms than upper-story bedrooms, while *D. farinae* concentrations were similar in basement and upper-story bedrooms. On average, the basement bedrooms were probably wetter than the upper-floor bedrooms.

Cabrera et al. (6) noted that dehumidifier use in the Canary Islands significantly reduced mean mattress concentrations of the *D. pteronyssinus* allergen, a finding consistent with this study. However, Custovic et al. (7) noted that portable dehumidifiers did not significantly lower concentrations of *D. pteronyssinus* in carpet, mattress or sofa dust.

Note that least-squares mean *D. farinae*-allergen collections (Table 2) were almost four times greater in homes with feathered or furred pets than in homes without pets. Least-squares mean *D. pteronyssinus* collections were also significantly higher in homes with pets. Perhaps pets in homes may sometimes worsen asthma problems in an indirect fashion because their dander is an excellent source of food for dust mites. A United Arab Emirates study found that the relative risk of doctor-diagnosed asthma in children was 2.03 (95% confidence limit of 1.40–2.95) in 307 homes of families with pets as compared to 422 homes without pets (18).

The mean dust-mite-allergen concentrations in dust in this study (1.15 µg/g *D. farinae* and 0.72 µg/g *D. pteronyssinus*) are roughly comparable to those found in other studies from the northern USA. Lintner & Brame (8) reported mean dust allergen concentrations of 1.66 µg/g for *D. farinae* and 2.91 µg/g for *D. pteronyssinus* from samples taken in the midwestern USA. Wood et al. (19) reported a median allergen concentration of 1.215 µg/g for *D. farinae* and *D. pteronyssinus* allergens combined from dust taken from Baltimore area homes of asthmatics.

This study involved 313 dust samples in 45 homes. The allergen levels seen in this study are roughly comparable to other studies. Flooding did not seem to have a large effect on levels of either *D. farinae* or *D. pteronyssinus* allergen. The strongest relationship found in this study was that with the presence of pets, which was associated with significantly higher levels of both the *D. farinae* and *D. pteronyssinus* allergens.

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