

Deposition of cat (Fel d 1), dog (Can f 1), and horse allergen over time in public environments – a model of dispersion

Egmar A-C, Almquist C, Emenius G, Lilja G, Wickman M. Deposition of cat (Fel d 1), dog (Can f 1), and horse allergen over time in public environments – a model of dispersion.

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Background The occurrence and accumulation over time in public environments of cat, dog, and horse allergens was evaluated.

Methods Concentrations of animal danders were analyzed by ELISA and counter-current immunoelectrophoresis (CCIE).

Results Among factory-new mattresses, 15/17 contained detectable levels of cat and/or dog allergen, whereas no horse allergen was found although six of the mattresses were stuffed with horsehair. Dust from 15 used mattresses contained significantly higher concentrations of Fel d 1 and Can f 1 than the factory-new ones ($P < 0.001$). Allergen concentrations and titers correlated to the period of time that the mattresses had been tried by customers; $r_s = 0.52–0.77$, $P = 0.04–0.001$ (cat), $r_s = 0.38–0.48$, $P = 0.15–0.08$ (dog), and $r_s = 0.64–0.74$, $P = 0.008–0.003$ (horse). The increase over time occurred rapidly in highly frequented stores and after 3 weeks reached concentrations that have been found in homes where furred pets had formerly been kept or even the lower allergen scale of homes where pets were currently kept.

Conclusions The dispersion of allergens from furred animals to pet-free public places is likely to occur by deposition from people who have been in direct or indirect contact with pets, and high levels of such allergens seem to accumulate in a short period of time.

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Possession of cats and dogs has been reported in 23–34% of Swedish families with children (1, 2), and horseback riding is also common in Sweden, particularly among girls (3). High levels of cat and dog allergens have been found in dust from floors in homes with and without furred pets (4, 5), as well as in dust from nursery schools and schools (6–8). Exposure to pets in early childhood appears to be a risk factor for later sensitization to both cat and dog (1, 9). Thus, among schoolchildren aged 11–13 years, sensitization to cat and/or dog has been reported in 15–20% (10); among children with asthma, sensitization to such animals has been found in 50–70% (11). Hypothetically, exposure to pet allergen in a pet-free environment may maintain or even worsen allergic disease, since bronchial challenge with very low concentrations of inhalant allergens has been shown to activate markers of inflammation (12, 13).

This study aimed to examine the presence of cat and dog allergens in public environments, and the accumulation of allergen levels in sedimented mattress dust over time in such environments.

Material and methods

In the first part of the study, six furniture stores in Stockholm were selected. All of the furniture stores had a separate department for sales of beds and bedding. A test room where customers could try displayed beds with matching bedding was available. Seventeen factory-new, not yet unpacked mattresses ("new group") and 15 mattresses tried by customers ("old group") were included in one phase of the study. Six of the factory-new mattresses were stuffed with horsehair. The age of the mattresses included in the "old group" was based on the time they had been displayed for testing and

was estimated with assistance from the staff of the department. In the second part of the study, the accumulation of cat and dog allergens in another five factory-new mattresses was examined over 3 consecutive weeks in the most frequently visited store. These five mattresses were not included in the first part of the study. All mattresses were of standard size; i.e., 1.8 m² (0.9×2 m).

Dust sampling

The mattresses in the "new group" were unwrapped in the stockroom of the furniture store, and the dust samples were immediately collected by vacuuming. Dust from the mattresses in the "old group" was collected in the test room. In the accumulation study, another four factory-new mattresses were placed on the beds, unwrapped, and immediately vacuumed. They were then vacuumed once a week and at the same time of the day for the following 3 weeks. A fifth mattress was used as a control and was only vacuumed once, after week 3. No cleaning of the mattresses by the staff was allowed during the study.

All dust samples were collected with the same vacuum cleaner (Volta Lite U 1840, Volta, Stockholm, Sweden). A suction mouthpiece and a filter were connected to the vacuum-cleaner tip (Allergologiskt Laboratorium, ALK, Hørsholm, Denmark) (14). Only one collector with a matching filter cassette was used per mattress. The dust sampling was standardized by time. The whole area of the mattress was vacuumed with long, even movements for 2 min. Thus, each square meter was vacuumed for 1 min. After use, the dust collectors were carefully washed, and new filter cassettes were applied.

The dust samples were kept at -20°C pending analysis (Allergologiskt Laboratorium/ALK, Hørsholm, Denmark). The dust was weighed and sieved, and the extract was prepared. Cat and dog allergen concentration was analyzed with ELISA based on monoclonal rabbit antibodies to Fel d 1 and Can f 1 and expressed in µg allergen per gram dust (µg/g) (15). The detection limit was set to 0.001 (Fel d 1) and 0.006 (Can f 1) µg/g dust. Polyclonal rabbit antibodies to horse allergen were analyzed with countercurrent immunoelectrophoresis (CCIE) and expressed in titers; i.e., the reciprocal value of the most diluted extract that yielded a precipitate (16). An increase of the titers from four to eight revealed a factor of two according to instructions given by the manufacturer. The cutoff level was set to one titer of horse allergen. Only dust from the six new mattresses stuffed with horsehair was analyzed for content of horse allergen.

Statistics

The concentrations of Fel d 1 and Can f 1 were given as median and range. In the second part of the study where the continuous adding of allergen to the mattresses from the surrounding environment was studied, accumulated absolute amounts (µg) of Fel d 1 and Can f 1 were used. Thus, the levels of Fel d 1 and Can f 1 obtained in the weekly vacuuming were added to previously obtained levels for these allergens.

A nonparametric test (Wilcoxon unpaired test) was used for comparative analysis and the Spearman-rank correlation (r_s) test for correlation. A two-sided test was used, and a value of $P < 0.05$ was considered significant.

Results

Fel d 1 was found in small concentrations, median 0.006 (range 0.001–0.016 µg/g), in dust from 15 of the 17 factory-new mattresses ("new group") (Fig. 1). Can f 1 was found in 16/17 of the new mattresses (median 0.81 [range 0.21–2.82 µg/g]) (Fig. 1). In contrast, horse allergen was not found in any new mattresses, although six of them were stuffed with horsehair. In the 15 mattresses tried by customers, Fel d 1 and Can f 1 were found in all dust samples (median concentrations 0.3 and 14.9 µg/g, respectively). The difference between concentrations of Fel d 1 and Can f 1 in the "new" and "old" mattresses was highly significant ($P < 0.001$) (Fig. 1). In at least three of the stores, dogs were occasionally present. However, the concentration

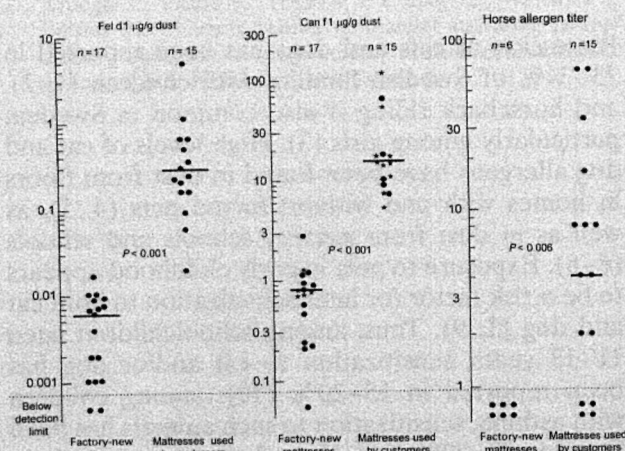


Fig. 1. Cat allergen (Fel d 1 µg/g), dog allergen (Can f 1 µg/g), and horse allergen (titer) in dust from factory-new mattresses and mattresses used by customers at six furniture stores in Stockholm, Sweden. Dotted line: detection limit; horizontal line: median concentration; ★: Can f 1 in mattresses from stores with dogs occasionally present.

of Can f 1 was not found to be higher in these stores than in the others.

Horse allergen was found in 11 of the 15 "old" mattresses in a titer ranging from 32 to 64 (median 4). The difference between "new" and "old" mattresses was significant ($P=0.006$) (Fig. 1).

The mattresses were available for testing for 2–78 weeks. There was a positive correlation between testing exposure time (weeks) and the concentrations/titers of animal danders (Fel d 1: $r_s=0.52$, $P=0.004$; Can f 1: $r_s=0.38$, $P=0.15$; horse: $r_s=0.64$, $P=0.008$) (Figs. 2–4). On exclusion of the results from the most frequented furniture store, where the mattresses had been displayed for only 3 weeks, a stronger positive correlation was found ($r_s=0.77$, $P=0.001$; $r_s=0.48$, $P=0.08$; and $r_s=0.74$, $P=0.003$ for Fel d 1, Can f 1, and horse allergen, respectively).

The amounts of Fel d 1 and Can f 1 in dust collected over 3 consecutive weeks in four mattresses are presented in Figs. 5 and 6. There was an increase, although it was not significant ($P=0.07$), in the concentrations of Fel d 1 in dust collected after 1 week of exposure of the mattresses in the test room (Fig. 5). During the following 2 weeks, the concentrations of Fel d 1 remained at approximately the same concentration ($\mu\text{g/g}$) in the weekly accumulated samples of dust in all four mattresses. However, there were increasing values in the absolute measures (μg) of Fel d 1 during the 3-week observation period. The accumulation of dog dander (Can f 1) followed the same schedule as Fel d 1, and the accumulations during the 3 weeks of Fel d 1 and Can f 1 were in the same range as those found in the "control" mattresses (Fig. 6).

Discussion

Allergens from cat, dog, and horse were found in all displayed test mattresses of the six studied

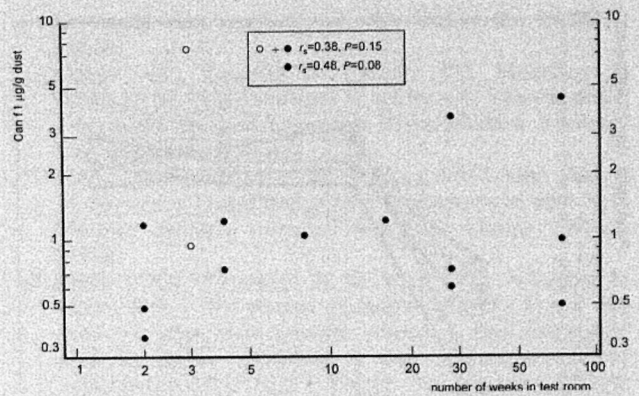


Fig. 3. Correlation between dog allergen (Can f 1 $\mu\text{g/g}$) in dust from 15 mattresses used by customers and time mattresses had been displayed for testing at six furniture stores. $\circ$: allergen concentrations in mattresses used by customers of most visited furniture store.

furniture stores. Furthermore, Fel d 1 and Can f 1 were found in most factory-new mattresses, although in very low concentrations. The longer the mattresses had been displayed for testing, the higher the concentrations of allergen. The source of the animal allergens found in dust from the used mattresses was assumed to be airborne. The allergens were probably disposed in the mattresses through dispersion from the customers, mainly from pets, clothes, and hair. Hypothetically, customers without pets at home may also have brought and deposited pet allergens at the bed department, since their clothes may have been contaminated by pet allergens from previous contact with pet owners. Our observations are in line with the results of the study by Munir et al. (7), who found allergens from mites, cats, and dogs on pupils' desks and chairs.

Mattresses containing horsehair were found not to have higher levels of horse allergen than mattresses without horsehair. This indicates that

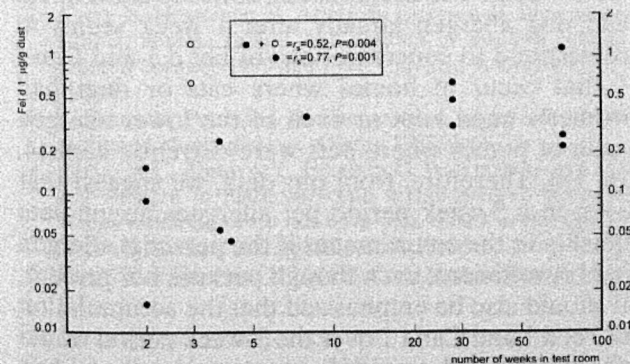


Fig. 2. Correlation between cat allergen (Fel d 1 $\mu\text{g/g}$) in dust from 15 mattresses used by customers and time mattresses had been displayed for testing at six furniture stores. $\circ$: allergen concentrations in mattresses used by customers of most visited furniture store.

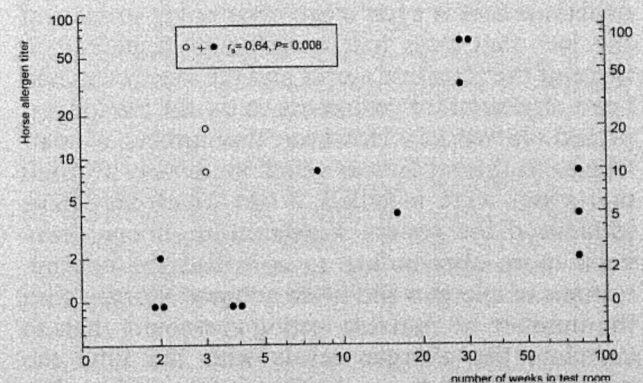


Fig. 4. Correlation between horse allergen (titer) in dust from 15 mattresses used by customers and time mattresses had been displayed for testing at six furniture stores. $\circ$: allergen concentrations in mattresses used by customers of most visited furniture store.

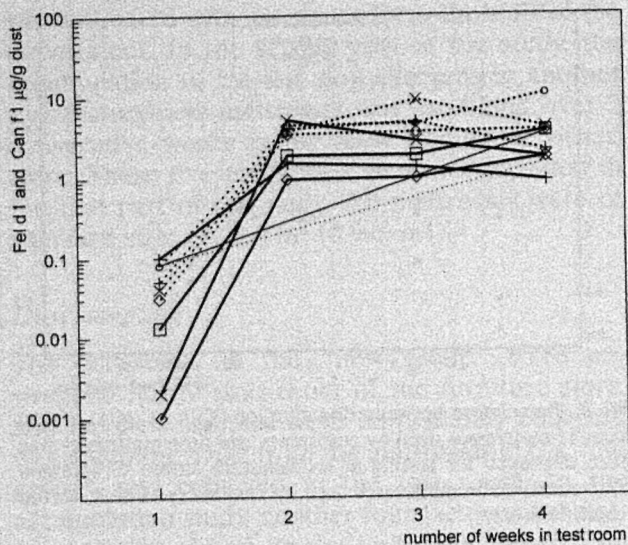


Fig. 5. Weekly concentrations of cat (Fel d 1 $\mu\text{g/g}$) and dog allergen (Can f 1 $\mu\text{g/g}$) in five mattresses displayed and used by customers collected over 3 consecutive weeks at furniture store. Solid thick line denotes cat allergen; hatched thick line: dog allergen. + mattress 1, vacuumed once a week for 3 consecutive weeks; $\diamond$ mattress 2, vacuumed once a week for 3 consecutive weeks; X mattress 3, vacuumed once a week for 3 consecutive weeks; $\square$ mattress 4, vacuumed once a week for 3 consecutive weeks. Solid thin line: cat allergen in control mattress, vacuumed only once after 3 weeks; thin hatched line: dog allergen in control mattress, vacuumed only once after 3 weeks. 0 (zero)-level is estimate of zero (0) median level of four mattresses.

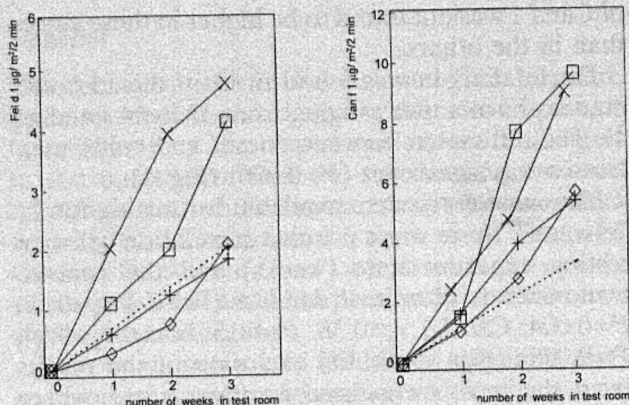


Fig. 6. Weekly contribution (accumulated dose) in μg of cat allergen, Fel d 1, and dog allergen, Can f 1, in five brand-new mattresses displayed and used by customers over 3 consecutive weeks at furniture store. + mattress 1, vacuumed once for 3 consecutive weeks; $\diamond$ mattress 2, vacuumed once for 3 consecutive weeks; X mattress 3, vacuumed once for 3 consecutive weeks; $\square$ mattress 4, vacuumed once for 3 consecutive weeks; ----- control mattress, vacuumed only once after 3 weeks. 0 (zero)-level is estimate of zero (0) median level of four mattresses.

allergens from horse had indeed been deposited by customers and not just been transferred from the interior of the mattresses. This highlights the importance of passive influx of pet allergens into buildings. Besides, a gradual and significant increase of Fel d 1 and horse allergen was found in dust samples from the mattresses that had been in use for 2–78 weeks. This time trend was not that clear for Can f 1. The difference is not easily explained and is even more astonishing in view of the fact that dogs had occasionally appeared in three of the furniture stores and the mattresses had been displayed for customers to try for the longest period (78 weeks). However, the number of mattresses in this study was small, since only 15 tried mattresses were included, a fact which may have influenced the results. Furthermore, it may have been more appropriate to correlate the concentrations of allergen and titers of horse allergen with the number of mattress-testing customers than to correlate the allergen levels with the time the mattresses had been displayed for testing. For practical reasons, this could not be done in this study.

Dust from the mattresses in the "new group" contained small, but still detectable allergen

concentrations of Fel d 1 and Can f 1. These low concentrations could derive from clothes of workers in the mattress factory with pets at home or with direct or even indirect contact with such animals outside home. However, it cannot be excluded that the allergens were partly sucked in from the surrounding air into the furniture store where the vacuuming took place. This is possible since cat and dog allergens, due to their smallness, have been reported to hover in the air for a long period of time (17).

The accumulation of cat, dog, and horse allergen was examined in one of the most frequently visited furniture stores. The deposition from dispersion of Fel d 1 and Can f 1 from clothes and hair of customers and staff seemed to be continuous over the 3 weeks. The accumulated concentration of cat and dog allergen already after 1 week seems to correspond to concentrations of Fel d 1 and Can f 1 that occur in homes where cats or dogs had formerly been kept or even of the lower allergen scale of homes where pets were currently kept (4, 18, 19). Therefore, from our data, we suggest that even in a 3-week period pet allergens accumulate quickly in the environment if the personal allergen load is sufficient, even though pets are not present. It should also be emphasized that the accumulation of Fel d 1 and Can f 1 over the 3-week period would not have been detected if concentrations ($\mu\text{g/g}$) had been used for expression of allergen exposure. Therefore, we suggest that allergen exposure is best expressed as $\mu\text{g}/\text{min}$ per m^2 , when changes over short periods are studied in a standardized fashion.

Our results could be applied to other public places such as day-care centers and schools where many children/pupils have pets at home and pet allergens may be transported to environments where many children spend their days (6, 7).

Low-grade exposure to airborne allergens can maintain or worsen allergic disease. The levels of cat and dog allergens found in this study may, considering the results from other studies (20), help maintain inflammation in the mucous membranes in the airways of patients sensitized to cat or dog with concomitant clinical allergy. Thus, it seems important to develop measures that permanently reduce the accumulated reservoir of cat and dog allergens and, furthermore, to take steps to reduce the inflow of pet allergens in public places such as department stores, day-care centers, and schools. However, it may be difficult to obliterate the reservoir of pet allergens as long as the dispersion followed by accumulation of allergens seems to be more or less continuous. There are studies that show fewer symptoms and less bronchial hyperactivity in allergic patients with asthma if they are taken away from the allergens that cause the symptoms (21). This makes it tempting to recommend a reduction of pet-owning for children in nursery schools and ordinary schools in order to decrease the influx of allergens from furred pets. Presumably, such a measure would have practical consequences and might be questionable for ethical and social reasons. Consequently, finding methods to decrease the exposure to furred pet allergens, especially among children with allergic symptoms who are sensitized to furred pets, must be considered important and should be studied.

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