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Exposure to an abundance of cat (Fel d 1) and dog (Can f 1) allergens in Swedish farming households

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Background: Earlier studies have shown that farmers are to a low degree sensitized to animal allergens. We have measured the amount of cat (Fel d 1) and dog (Can f 1) in farm households and examined the relationship between exposure and sensitization to cat and dog allergens.

Methods: Dust samples from the homes of 403 farmers who had participated in an epidemiologic follow-up study on respiratory symptoms were analyzed for allergen content by two-site ELISA methods.

Results: Fel d 1 was detected in 99.5% of the farmers' households ranging from 0.055 to 1455 µg/g dust in mattresses (GM 13.2) and to 3775 µg/g dust in living-room carpets (GM 17.1). Can f 1 was detected in 90.6% of the households from 0.2 to 116 µg/g dust in mattresses (GM 2.0) and to 504 µg/g dust in carpets (GM 4.3). Homes with pets present had the highest levels of the allergens ($P<0.001$). A total of 8.4% and 7.4% of the farmers were sensitized to cat and dog, respectively. A significant correlation was noted between exposure to the allergens and specific IgE to cat and dog, respectively ($P<0.001$). Sensitization to cat (OR=4.9) and dog (OR=17.8) was significantly associated with asthma.

Conclusions: In spite of the abundance of Fel d 1 and Can f 1, farmers are only to a low degree sensitized to cats and dogs.

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Several studies have shown that exposure to indoor allergens derived from furred pets is an important cause of respiratory allergy (1, 2). A recent study from Sweden, performed as part of the European Community Respiratory Health Survey, has demonstrated a higher prevalence of sensitization to domestic animals, especially to cats, than sensitization to other indoor allergens such as mites (3), probably due to both

the increase in cat ownership and the fact that many cats are kept indoors.

The major cat (Fel d 1) and dog (Can f 1) allergens have been detected in dust samples collected from both mattresses and carpets, not only in homes where pets are kept, but also in homes where pets are not kept (4–7). Occasional visits by pet owners to homes with no pets is a way to transfer indirectly the allergens into these homes, and can sometimes result in significant allergen concentrations (4, 6). Exposure to cat and dog allergens can also occur in schools, hotels, or cinemas, or on public transport (6, 8, 9).

Although an exposure level of 8 µg/g of dust has been suggested as the risk threshold for sensitization to Fel d 1 (10, 11), several studies have shown that sensitization can occur at lower allergen levels (12, 13). A risk level has not yet been established for Can f 1, but a recent study by Ingram et al. (6) proposed 10 µg Can f 1/g dust to be a significant exposure level, since most asthmatic patients allergic to dog experienced symptoms when exposed to dog allergen at this level.

Regarding exposure to indoor allergens, most studies have monitored the indoor environment in urban homes and public places, but the indoor environment in farm households has not yet been examined. Most farmers keep cats and dogs, either in their home or outside the dwelling. Since farm families are daily exposed to Fel d 1 and Can f 1, one could anticipate a high rate of sensitization to these allergens.

In 1996, we performed a 12-year follow-up survey of allergic respiratory diseases among Swedish farmers on the island of Gotland in the Baltic Sea. The aims of the present study, which is part of the follow-up survey, were to investigate the concentrations of Fel d 1 and Can f 1 in farm households, and to examine the relationship between exposure and sensitization to cat and dog allergen.

Material and methods

Subjects

A total of 403 farmers who participated in the 1996 epidemiologic follow-up study on respiratory symptoms among farmers on the island of Gotland (14) took part in this study. All subjects had completed a questionnaire on symptoms from upper and lower airways and exposure to cat and dog. In addition, they had attended a medical examination, which comprised a structured interview, skin prick tests (SPT) (ALK Soluprick), and blood sampling for

determination of IgE antibodies to common aeroallergens (Pharmacia CAP System RAST FEIA).

According to the results from the questionnaire and the medical examination, asthma was present in 73 farmers and rhinoconjunctivitis in 222; 129 farmers were asymptomatic. Thirty-four subjects were sensitized to cat and 30 to dog. (Sensitization was defined as at least a positive SPT [2+ and at least 3 mm] and/or a positive RAST [≥ 0.35 kU/l].)

Dust sampling and extraction

Dust samples were collected from bed mattresses and living-room carpets. The farmers were instructed to use their own vacuum cleaners with a new dust bag, and to vacuum-clean 1 m² for 2 min. A separate filter bag (Medeca AB, Uppsala, Sweden) was inserted into the inlet tube of the vacuum cleaner for each sampling site. The subjects were advised not to vacuum-clean their mattresses and carpets for 14 days before collection of dust. After collection, the filter bags were sealed in plastic bags and stored at –20°C until extracted. All dust samples were sieved through a 300-µm mesh screen and weighed. A total of 50–100 mg of fine dust was extracted (1/20 w/v) in phosphate-buffered saline containing 0.1% Tween 20 by rotation overnight at 4°C. The samples were then centrifuged at 3500 rpm for 15 min, and the supernatants were isolated and centrifuged again for 5 min at 10 000 rpm. The supernatants were finally stored at –20°C until analysis of allergen content.

A total of 315 farmers out of the 403 delivered dust samples at the time of the medical examination, which was carried out in April, and the other 88 subjects sent their samples to the laboratory between April and November the same year. Sufficient dust for analysis (≥ 50 mg) from mattresses and carpets was available for 350 and 353 Fel d 1 assays, respectively, and 351 and 361 Can f 1 assays, respectively. At least one sample (mattress or carpet) from 403 households was available for Fel d 1 and Can f 1 analysis.

Allergen assay

Cat (Fel d 1) and dog (Can f 1) allergen content was determined by a two-site ELISA using monoclonal and/or polyclonal antibodies. The assays were performed according to the protocols from Indoor Biotechnologies, VA, USA (Professor Martin D. Chapman) except that peroxidase-labeled conjugates were replaced with ALP-labeled streptavidine (DAKO, Denmark).

Table 1. Distribution of Fel d 1 and Can f 1 levels in mattresses and carpets

Fel d 1 ($\mu\text{g/g}$)	Mattresses <i>n</i> =350 (%)	Carpets <i>n</i> =353 (%)
ND (<0.055)	1 (0.3)	2 (0.6)
0.055–8	133 (38.0)	128 (36.3)
8–100	147 (42.0)	140 (39.7)
≥ 100	69 (19.7)	83 (23.5)

Can f 1 ($\mu\text{g/g}$)	Mattresses <i>n</i> =351 (%)	Carpets <i>n</i> =361 (%)
ND (<0.200)	63 (17.9)	55 (15.2)
0.200–10	197 (56.1)	145 (40.2)
10–100	87 (24.8)	137 (38.0)
≥ 100	4 (1.1)	24 (6.6)

ND: none detected.

The extracts were assayed in duplicate at 2.5-fold dilution and reanalyzed if they differed by more than 10%. Allergen concentrations were expressed as $\mu\text{g/g}$ of fine dust. Dust samples with Fel d 1 levels below the detection limit (0.055 $\mu\text{g/g}$) were assigned a value of 0.054 $\mu\text{g/g}$, and Can f 1 levels below the detection limit (0.200 $\mu\text{g/g}$) were assigned 0.199 $\mu\text{g/g}$ for statistical analysis.

Statistical methods

Allergen levels are expressed as the geometric mean (GM) and range values. Due to the skewed distribution of the material, nonparametric statistical methods were used. The Mann-Whitney U test was used to determine the levels of significance between two groups, and the comparison between three groups was done by the Kruskal-Wallis test, illustrated by box plots. The Spearman rank correlation was used to determine the correlation between exposure and sensitization. The impact of allergen exposure in relation to symptoms was analyzed by multiple logistic regression with adjustment for symptoms, allergen levels, and sensitization. The odds ratio (OR) is expressed with corresponding 95% confidence interval (CI). If the CI does not include 1.0, the results are considered statistically significant at $P < 0.05$.

Ethical considerations

The study was approved by the ethics committee of the Karolinska Institute in Stockholm, Sweden.

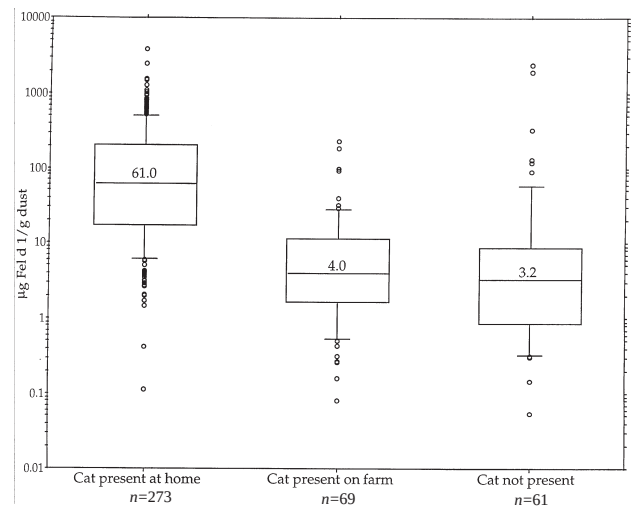


Figure 1. Concentrations of cat allergen (Fel d 1) in homes with cat present, with cat present on farm outside dwelling, and with cat not present. Fifty percent of each group is presented within boxes, and numbers given are geometric mean.

Results

Cat-allergen levels

Fel d 1 was present in almost all of the farmers' homes (401/403), ranging from 0.055 to 3775 $\mu\text{g/g}$ of fine dust (GM 24.4 $\mu\text{g/g}$) from either mattresses or carpets. Concentrations above 8 μg Fel d 1/g were found in 69.2% of the homes. Fel d 1 levels were higher in carpets (GM 17.1 $\mu\text{g/g}$; range 0.055–3775 $\mu\text{g/g}$) than in mattresses (GM 13.2 $\mu\text{g/g}$; range 0.055–1455 $\mu\text{g/g}$), but the difference was not significant. In addition, 19.7% of the mattresses and 23.5% of the carpets contained allergen levels above 100 $\mu\text{g/g}$ of dust (Table 1).

To evaluate the influence on the levels of Fel d 1 of keeping a cat, dust from homes with cat at home (67.8%), cat on the farm outside the dwelling (17.1%), and homes without cat (15.1%) were compared. Fig. 1 shows the Fel d 1 levels and the GM values in dust samples from the three different categories. High allergen concentrations (above 8 $\mu\text{g/g}$) were detected in 240 (87.9%) homes with cat, 32 (33.3%) homes with cat outside the dwelling, and 16 (26.2%) homes without cat. The lowest allergen levels were found in samples from homes without cat present or with cat present outside the dwelling. However, one of the highest values was detected in dust from a home where no cat was kept. A significant difference in levels of Fel d 1 was found between homes keeping cat at home and homes where cat was present on the farm and homes without cat ($P < 0.001$).

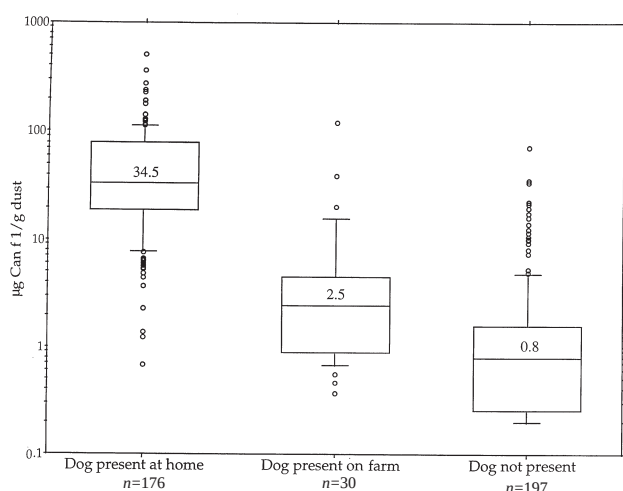


Figure 2. Concentrations of dog allergen (Can f 1) in homes with dog present, with dog present on farm outside dwelling, and dog not present. Fifty percent of each group is presented within boxes, and numbers given are geometric mean.

The GM values of Fel d 1 among the 34 cat-sensitized and 369 nonsensitized subjects were 21.6 and 24.6 µg/g, respectively. A total of 22 cat-sensitized subjects and 257 nonsensitized subjects were exposed to allergen levels above 8 µg per g of dust. Of the sensitized subjects, 64.7% kept cat at home, and the corresponding figure for the nonsensitized subjects was 68.0%.

Dog-allergen levels

Can f 1 was detectable in 365/403 of the farmers' homes, ranging from 0.2 to 504 µg/g of fine dust (GM 4.4 µg/g) from either mattresses or carpets. Concentrations above 10 µg Can f 1/g were found in 42.9% of the homes. The Can f 1 levels detected in dust from carpets (GM 4.3 µg/g; range 0.2–504 µg/g) were significantly higher than those in mattresses (GM 2.0 µg/g; range 0.2–116 µg/g) ($P<0.001$). Concentrations above 10 µg Can f 1/g were found in 44.6% of the carpets and 25.9% of the mattresses (Table 1).

Fig. 2 shows levels and GM values of Can f 1 in samples obtained from homes with dog at home (43.7%), with dog present on the farm (7.4%), and homes without dog (48.9%). Concentrations above 10 µg/g were found in 155 (88%) of homes with dog present, in five (16.7%) of those with dog on the farm, and in 13 (6.6%) of homes without dog present. The lowest allergen levels were found in samples from homes without dog present, even though high levels of Can f 1 were detected in some samples from this category. Significantly higher levels of Can f 1 were found in samples from homes with dog at home than those

Table 2. Odds ratio (CI 95%) from logistic regression model for airway disease in relation to cat and dog

		Asthma	Rhinoconjunctivitis	No symptoms
Cat	NS	1.00*	1.00*	1.00*
	S	4.9 (1.8–13.5)	2.4 (0.9–6.1)	0.4 (0.2–1.1)
Dog	NS	1.00*	1.00*	1.00*
	S	17.8 (3.9–80.9)	8.0 (1.9–34.6)	0.1 (0.03–0.6)

*Reference value.

NS: nonsensitized; S: sensitized.

from the other two categories ($P<0.001$). In addition, there was a significant difference between Can f 1 levels in homes with dog on the farm and those without dog present ($P<0.001$).

Among the 30 dog-sensitized and 373 nonsensitized farmers, the GM values of Can f 1 were 3.7 and 4.5, respectively. Allergen levels above 10 µg were found in the homes of 11 sensitized farmers and in 162 homes of the nonsensitized farmers. The figures for keeping dog at home were almost the same among sensitized and nonsensitized farmers, 40.0% and 39.1%, respectively.

Exposure, sensitization, and symptoms

Among the sensitized farmers, we found a moderately strong correlation between the Fel d 1 and Can f 1 levels and the values for the corresponding specific IgE to cat ($r=0.41$, $P<0.001$) and dog ($r=0.44$, $P<0.001$).

Since nearly all dog-sensitized subjects (28/30) had asthma or rhinoconjunctivitis, the role of other determinants of asthma such as exposure could not be assessed by multiple logistic regression.

Sensitization to cat was found to be significantly associated with asthma (OR=4.9 CI: 1.8–13.5). We also obtained a significant association between sensitization to dog and asthma (OR=17.8 CI: 3.9–80.9) and rhinoconjunctivitis (OR=8.0 CI: 1.9–34.6) (Table 2).

Seasonal variation in allergen levels

We did not observe any seasonal differences in the levels of Can f 1 and Fel d 1, between samples delivered in April and those sent in between April and November. The relationship between Fel d 1 and Can f 1 levels from these two groups and different symptoms was also examined using multiple logistic regression, but no differences were found.

Discussion

An important finding in this large survey of 403 households was that almost two-thirds of the farmers were exposed to Fel d 1 levels higher than the proposed level of sensitization (8 µg/g) (10, 11) and nearly one-third to Can f 1 levels above the suggested level of significant exposure (10 µg/g) (6). Interestingly, Fel d 1 concentrations above 100 µg/g were observed in 20% of the samples. Our Fel d 1 levels were higher than those of several other studies on allergen exposure, but the Can f 1 concentrations were approximately in the same range as allergen levels reported earlier (6, 13, 15–17).

We found that allergen levels detected in living-room carpets were higher than those in mattresses, a finding that has earlier been reported by Munir et al. (18) and Christiansen et al. (19), indicating that carpets may be reservoirs of pet allergens. Although measurement of mattress and carpet dust does not reflect the actual amount of allergen entering the airways, reservoir measurements have been proposed as the most appropriate available index of exposure (20). As could be expected, we observed the highest concentration of Fel d 1 and Can f 1 in samples from homes where cats or dogs were present, but notably high values were found in homes with the pets outside the dwelling. However, high allergen levels were also recorded in homes without pets present, which is in accordance with several other studies where it is suggested that allergens found in places without cats or dogs present are due to passive transport by occasional visits by pet owners, with or without their pets, or by the inhabitants themselves (4, 7). Since owning furred pets is common in Sweden, above all in the rural environment, a passive transfer of the allergens by the inhabitants or visitors is unavoidable.

We obtained no difference in allergen levels between sensitized and nonsensitized subjects, which is in agreement with the results of Ingram et al. (6). However, we obtained a moderately strong correlation between exposure levels and specific IgE antibodies to cat and dog. Since 68% of the farmers in our study group were exposed to Fel d 1 levels greater than 8 µg/g and 43% to Can f 1 levels above 10 µg/g, we expected the number of subjects sensitized to cat (8.4%) and dog (7.4%) to be higher. Furthermore, almost 90% of farmers who kept a cat at home were exposed to Fel d 1 levels above thresholds, but only 6.7% were sensitized to cat. The corresponding figure for dog was 7.1%. The reason for the low degree of sensitization to pets could be

uncertainty as to when sensitization actually occurred; it is reasonable to assume, however, that the exposure to cats and dogs has not changed greatly over time. Another explanation could be that even though there is an abundance of cat and dog allergens in farming households, the levels were still too low for sensitization. However, earlier studies from Sweden have demonstrated that sensitization can occur at much lower levels than these suggested risk levels (13, 21). Finally, farmers smoke less than the general population (22, 23), as we have observed also among these farmers (14), and tobacco smoke has been shown to be the single most important environmental risk factor for sensitization (24).

We found that sensitization to cat and/or dog was strongly associated with asthma. Gelber et al. have also reported that IgE antibodies to cat were significantly associated with asthma (2). Furthermore, Sears et al. demonstrated that sensitivity to cat, but not dog, danders is a highly significant independent risk factor associated with the development of asthma (25). Boulet et al. recently suggested that the expression of different allergic symptoms depends on the type of allergen that give rise to sensitization. They showed that pollens were more related to rhinitis, while sensitization to indoor allergens such as cat, dog, and mites seems to be more crucial for the development of allergic asthma (26).

The role of seasonal variation of pet allergens in exposure and sensitization has been discussed earlier by Quirce et al. among others, who described a seasonal influence on the levels of indoor allergens (17). However, we were not able to demonstrate any difference between allergen levels in dust samples collected in April and those delivered later the same year. This suggests that farmers on Gotland are probably exposed equally all year round to high quantities of allergen.

In summary, even though farmers on the island of Gotland are exposed to an abundance of cat and dog allergens, the figure for sensitization to pets remained low. Nonetheless, sensitization to cat or dog was significantly associated with asthma.

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