

Allergen content in dust from homes and schools in northern Norway in relation to sensitization and allergy symptoms in schoolchildren

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Summary

Background Previous studies have shown a high prevalence of atopic diseases among school children in the community of Sør-Varanger. Moreover, animal dander followed by pollen and house dust mite, were the most common allergens in skin prick tests.

Objective To assess the allergen content in homes (living-rooms and mattresses) and classrooms of children living in an arctic area at 70° north. The presence of allergens in homes and schools and their relationship to atopy was of particular interest.

Methods Dust samples from 38 homes and seven schools in northern Norway were collected by vacuum cleaning. The presence of allergens of dog, birch, timothy, *Cladosporium herbarum*, codfish and hen egg-white was investigated by radio-allergosorbent test (RAST) inhibition and the presence of major allergens of cat *Felis domesticus* (*Fel d* I) and house dust mites (HDM) *Dermatophagoides pteronyssinus* (*Der p* I) and *Dermatophagoides farinae* (*Der f* I) by enzyme-linked immunosorbent assay (ELISA).

Results Mattresses contained significantly more dust per unit area than living-rooms and classrooms. No statistically significant differences in allergen content for dog, birch, timothy, *Cladosporium*, codfish and hen egg-white were seen between HDM-sensitized and non-atopic children. Most dust samples contained dog allergens with the highest allergenic activity found in living-rooms of those keeping dogs. An increased level of *Fel d* I was detected in only one of 38 samples from living-rooms (this family kept a cat) and in 25 of 38 samples from mattresses with ranges from 24 to 84 ng/m². The highest concentrations were found in mattresses of children keeping cats. Increased levels (≥ 25 ng/m²) of *Der p* I were found only in homes and virtually only in mattresses of HDM-sensitized children. An increased level of *Der f* I was found in only one case, i.e. in the mattress of an HDM-sensitized child where additionally *Der p* I and HDMs were demonstrated microscopically. When relating *Der p* I to HDM-sensitization an odds ratio of more than 16 (95% CI: 1.6–394.3) was found. All extracts from living-rooms included codfish allergens. Low RAST inhibition values were detected for hen egg-white, *Cladosporium*, birch and timothy pollen in most samples. Furthermore, the study demonstrated that dust from schools was relatively free of allergens.

Conclusion Previous findings indicating that the main allergen exposure problem in this geographical area is that of pet allergens were confirmed.

Keywords: allergens, atopy, classrooms, *Dermatophagoides pteronyssinus*, ELISA, floor dust, house dust mite, humidity, living-rooms, mattresses, pets, RAST inhibition, school-children.

Clinical and Experimental Allergy, Vol. 27, pp. 252–261. Submitted 4th April 1995; accepted 20 July 1996.

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Introduction

House dust as a mixture of biological materials has been known as a major cause of allergic diseases for more than 70 years [1,2]. IgE sensitization and symptoms of atopic diseases have been attributed to protein components in house dust such as pollen, animal dander, moulds and domestic mites [1,3–8]. Inorganic compounds and other irritants in dust seem to enhance the sensitization process and the inflammatory skin and mucosa symptoms [9–11].

Over the past few decades epidemiological studies from many industrialized countries have indicated an increasing prevalence of atopic diseases [12–15]. Recent studies have shown that atopic diseases are twice as frequent in the children investigated than in their parents [14,15]. The increasing prevalence may be explained by changes in lifestyle and diet, in addition to exposure to environmental factors [6,7,11–13]. Passive smoking in early infancy, combined with high indoor humidity and environmental allergens, seems to be particularly harmful [9,11].

The present study is concerned with the correlation of allergen amounts in living-rooms and mattresses in homes and classrooms of children living in an arctic area on 70° north and, furthermore, the proportion of major allergens of *Dermatophagoides pteronyssinus* (*Der p* I) and *Dermatophagoides farinae* (*Der f* I) compared with mite counts in mattresses. Special attention was given to the occurrence of house dust mite (HDM) allergens in homes of HDM-sensitized children. Of particular interest was the presence of other allergens than HDM in schools and homes and their relationship to atopy.

Materials and methods

Dust collection and patients

Dust samples were collected from living-rooms and mattresses in 19 homes of HDM-sensitized children and in 19 homes of non-atopic children as a control group during January and March 1994. The atopic and non-atopic children were matched for age, sex and residential area. All 38 children were selected from 424 schoolchildren aged 7–12 years living in the community of Sør-Varanger, northern Norway, as described in detail previously [15]. Additional dust samples were similarly collected from 14 classrooms in seven schools in the same area. The average outdoor temperature was between -4.5° and -13.5°C and the mean relative humidity between 85 and 90%, corresponding to an absolute outdoor humidity between 1.6 and 2.8 g/kg during the months of investigation (personal communication, Norwegian Meteorological Institute, Oslo, Norway).

In this study atopic children are defined as those having current or past histories of atopy, including atopic dermatitis

(AD) and/or mucous membrane atopy (MMA). Atopic dermatitis was defined according to the criteria of Hanifin & Rajka (16). A diagnosis of MMA was confirmed if the child had a history of asthma and/or allergic rhinoconjunctivitis in response to known or strongly suspected allergens [15]. Children with positive skin prick test(s) (SPT) with no clinical history of atopic diseases were defined as latent atopics [17].

Completed questionnaires were obtained from all homes and schools on the day of the investigation, focusing on type of building, location, number of family members, pets, family smoking habits, carpeted floors, insulation, renovation and the child's living conditions before the age of 2. Special attention was given to the ventilation system, damp patches, e.g. condensation on windows, and previous water leakages.

Absolute indoor humidity (AIH) was calculated from simultaneous measurements of relative humidity and indoor temperature (Mollier diagram) using a calibrated thermohygrometer (Therm 2250-1 No. 887944, Ahlborn Meß- und Regelungstechnik, Holzkirchen, Germany) and a standard swingpsychrometer (S. Brannan and Son Ltd, Cleator Moor, Cumbria, UK).

Dust samples were collected by vacuuming a 12 m² floor area in living-rooms (centre of the room/TV area) and classrooms for a total of 9 min. Two dust samples were collected from each mattress. Each dust sample was vacuumed from half of the upward facing surface and vertical side of the child's mattress and inside of the bed for a total of 1.5 min. A nozzle (Allergologisk Laboratorium A/S, Hørsholm, Denmark) was connected to the inlet of the suction tube of a household vacuum cleaner (Nilfisk GM 90, Fisker and Nielsen A/S, Copenhagen, Denmark). According to the manufacturer, the nozzle was fitted with a Whatman qualitative filter paper grade 1 (Cat. No. 1001070, Whatman International Ltd, Maidstone, UK) with a diameter of 7.0 cm and with a pore size retaining 97% of particles between 0.5 and 1.0 μm . The nozzle was carefully cleaned and a new filter paper fitted before each sampling. The parents had been instructed not to vacuum mattresses or floors for 1 week prior to sampling. Each dust sample was sealed in a plastic bag and stored at -18°C until preparation. Dust samples were weighed and extracted with 12 ml phosphate buffered saline containing 0.05% Tween 20, pH 7.4, for 24 h at 4°C , with shaking. The extracts were centrifuged at 3000 r.p.m. and 4°C for 30 min. The supernatant fluids were stored at -18°C until analysed.

Human sera

Pooled human sera from patients with Type I allergy were used in the radio-allergosorbent test (RAST) inhibition and have been described previously [15,18,19].

Skin prick test and radio-allergosorbent test

The SPT was performed on the volar forearm according to previous recommendations [20] and read after 15 min by the same dermatologist (L.K.D.). Eleven commercially available allergen extracts (ALK, Hørsholm, Denmark), including *Der p*, dog, cat, *Cladosporium herbarum*, birch, timothy, mugwort, white flour, cow's milk, codfish and egg-white, were used. The SPT was regarded as positive when the wheal size was at least half of the histamine reaction ($\geq 2+$), except for cow's milk and white flour, where a reaction of $\geq 3+$ was required to be considered positive [21]. Sera obtained from all the 38 children were subjected to total IgE analyses (Pharmacia CAP System, IgE-FEIA; Pharmacia AB, Uppsala, Sweden) and specific IgE antibodies (Pharmacia CAP System, Pharmacia).

Microscopy of domestic mites

Domestic mites in the dust samples from mattresses were counted and identified microscopically and expressed as number of mites/g dust as previously described [22].

Protein analysis

Protein concentration in the dust samples was estimated using the Bio-Rad DC protein assay kit (Bio-Rad Laboratories, Hercules, CA, USA). Bovine serum albumin was used as a standard [23].

Allergen discs

Allergen paper discs were purchased from Pharmacia AB.

Radio-allergosorbent inhibition test

Radio-allergosorbent test inhibition was used to express the allergenic activity of the following allergen sources in the extract: dog, *Cladosporium*, birch, timothy, egg-white and codfish [18,19]. The 50% inhibition was not calculated due to the low concentrations and great variation in the content of allergens in the extracts. Dust extract solutions corresponding to dust from 0.1 m² of floor area and 0.01 m² of mattress area were compared. Aliquots of 100 μ l dust extract were added to 50 μ l of patients' pool of sera and incubated for 1 h at room temperature. An allergen disc coated with the appropriate allergen was added to the mixture and incubated for 3 h. The disc was further incubated overnight with 50 μ l ¹²⁵I-labelled anti-IgE (Phadebas RAST isotope, Pharmacia). The tests were performed in duplicate. The per cent inhibition was calculated by the formula (c.p.m. of non-inhibited serum – c.p.m. of inhibited serum)/(c.p.m. of non-inhibited serum) $\times$ 100. Inhibition values of 10% or more were considered to be significant.

Enzyme-linked immunosorbent assay (ELISA)

All samples were analysed for the major allergens *Felis domesticus* (*Fel d* I), *Der p* I and *Der f* I as described elsewhere [24,25]. Reagents for the sandwich ELISAs were gratefully received from Dr Martin D. Chapman (University of Virginia, Charlottesville, VA, USA). Reference cat dander preparation OBRR Cat E3 was obtained from Dr Christine Anderson (Office of Biologics and Research Resources, Department of Health and Human Services, Bethesda, MD, USA). The detection limits of the assays are 1 ng. Some of the samples, however, contained very low dust concentrations per unit area, resulting in uncertainty with respect to the measured allergen content. According to previous studies [6,8,19,24] allergen levels of 12 ng/m² for both *Fel d* I and *Der f* I and 25 ng/m² for *Der p* I were chosen as cut-off levels, i.e. values above these were considered increased.

Statistics

The data were manually computed followed by use of the Wilcoxon one- and two-sample tests to evaluate group differences. The odds ratio (OR) and a confidence interval (CI) of 95% using the Mantel–Haenszel test are also indicated. If the 95% CI does not include 1.0, the results are statistically significant at $P < 0.05$. The study was approved by the Ethical Committee of Tromsø University.

Results

The weight of the total vacuumed dust material per m² of sampled area in homes and schools varied widely, from 6 to 1643 mg (Table 1). Likewise, the physical appearance of the samples varied from small amounts of fine dust to large quantities of hair, fluff, crumbs, etc. The mean weight of the vacuumed material per m² was five times higher from mattresses than living-room floors. The latter was five times higher than that found in classrooms, and both differences were highly significant ($P < 0.0001$). The protein content and mean weight of dust were higher in the HDM-sensitized group than in the control group, but the differences were, however, not statistically significant (Table 1). Only small quantities of dust and protein were found in the classrooms (Table 1).

Positive SPTs occurred more frequently in children with AD combined with MMA than in any other group (Table 2).

The percentage RAST inhibition in dust extracts from 0.1 m² of floor area and 0.01 m² of mattress area are shown in Table 3. No significant difference in allergenic activity of dog, birch, timothy, *Cladosporium*, codfish and egg-white

Table 1. Weights of vacuumed material and protein concentration/m² of floor area after sampling in 38 homes and 14 classrooms

	HDM-sensitized group (<i>n</i> = 19)		Control group (<i>n</i> = 19)		Classrooms (<i>n</i> = 14)
	Living-rooms	Mattresses	Living-rooms	Mattresses	
Vacuumed material (mg)	93 ± 182 (19–826)	374 ± 306 (25–1130)	58 ± 29 (16–120)	356 ± 411 (13–1643)	14 ± 8 (6–31)
Protein (mg)	1 ± 1 (0.2–4)	15 ± 13 (0–42)	1 ± 1 (0–3)	9 ± 11 (0–30)	0.1 ± 0.1 (0–0.4)

P < 0.001, comparison between mattresses (M) and living-rooms (L) for vacuumed material in house dust mite (HDM)-sensitized group;

P < 0.0001, comparison between M and L for vacuumed material in control group;

P < 0.0001, comparison between M and L for protein concentration in HDM-sensitized group;

P < 0.005, comparison between M and L for protein concentration in control group;

P < 0.01, comparison between HDM-sensitized group and control group vs classrooms for amount of vacuumed material and protein;

Arithmetic mean ± s.d., range and *P* values are indicated.

Table 2. Positive skin prick test reactions in 19 house dust mite-sensitized schoolchildren from northern Norway

Allergen	Latent atopy (n = 4)	AD (n = 4)	AD with MMA (n = 6)	MMA (n = 5)
<i>Dermatophagoides pteronyssinus</i>	4	4	6	5
Dog dander	2	2	3	1
Cat dander	3	2	3	2
<i>Cladosporium herbarum</i>			1	
Birch pollen		1	1	
Timothy pollen		1	3	1
Mugwort pollen		1		
Food		2		

AD, atopic dermatitis; MMA, mucous membrane atopy.

was shown between the HDM-sensitized and the control group (results not shown).

Dog allergenic activity as confirmed by RAST inhibition is shown in Table 3 and Fig. 1. Living-rooms contained significantly more dog allergens per unit area than mattresses ($P < 0.0001$) and classrooms ($P < 0.002$) (Table 3). Higher dog allergenic activity was found in extracts from both living-rooms and mattresses in the homes of families with than without dogs ($P < 0.01$) (Fig. 1). On the other hand, there was no association between allergenic activity, history of atopy and/or sensitivity to dogs (results not shown).

With the exception of three samples from mattresses, which gave RAST inhibitions for birch of 38, 39 and 45%, respectively, the dust extracts tested showed low RAST inhibition values for birch and timothy pollen in both homes and schools (Table 3).

Low allergenic activity of *Cladosporium* was detected in 13 of the 38 samples from living-rooms and in 10 of the 38 samples from mattresses, but none of the samples reached a RAST inhibition of 50%.

Codfish allergens were detected in most extracts and with higher values in both living-rooms and mattresses than in classrooms ($P < 0.005$) (Table 3). Allergenic activity of egg-white was found infrequently, indicating the presence of only minor amounts of allergenic material.

Eight families kept cats and additionally seven had previously kept cats. A significantly higher content of *Fel d* I was found in living-rooms ($P < 0.001$) and mattresses ($P < 0.0005$) in homes with than without cats (Fig. 2). Homes with as well as without cats showed a higher content of *Fel d* I in mattresses than in living-rooms ($P < 0.01$) and classrooms ($P < 0.0001$). In homes without cats, however, all 17 families had close relatives or neighbours keeping cats or they had previously kept cats themselves. The *Fel d* I

content in floor dust from classrooms was higher than that in living-rooms of families without cats, but lower than in those with cats ($P < 0.05$). No correlation was found between *Fel d* I content in homes and sensitivity to cats (results not shown). When relating atopic symptoms to previous or present keeping of cats, an OR of 1.6 (95% CI: 0.4–7.7) was found.

The *Der p* I contents in ng/m^2 of floor area in homes and classrooms are shown in Fig. 3. Increased levels ($\geq 25 \text{ ng/m}^2$) of *Der p* I were found in nine homes of HDM-sensitized children compared with none in the control group, corresponding to an OR of more than 16 (95% CI: 1.6–394.3). *Der p* I values of $\geq 25 \text{ ng/m}^2$ were found in dust samples from nine mattresses of HDM-sensitized children of which one home additionally had a detectable allergen content (35 ng/m^2) in a dust sample from the living-room (Fig. 3). The rest of the samples had no detectable contents of *Der p* I. Significantly more *Der p* I allergens were demonstrated in mattresses of HDM-sensitized children than in any other group ($P < 0.005$) (Fig. 3). The relationship between detectable mite allergen, *Der p* I in ELISA test and *D. pteronyssinus* identified microscopically is given in Table 4. Domestic mites were demonstrated microscopically in the mattresses of 10 HDM-sensitized children compared with none in the control group (OR ≥ 20 , 95% CI: 2.0–487.7). Nine of the 10 mattresses were infested with *D. pteronyssinus* and one with the storage mite *Acarus siro*. Six samples from the mattresses of these 10 children showed increased levels of *Der p* I allergen alone and one mattress sample had increased levels of both *Der p* I and *Der f* I allergen. In fact, an increased level of *Der f* I was found only on this occasion, i.e. in the mattress of an HDM-sensitized atopic child. In two of the remaining three mattresses *D. pteronyssinus* (10 and 200 mites/g, respectively) and in one mattress *Acarus siro* (10 mites/g) were demonstrated. In

Table 3. Allergenic activity expressed by percentage radio-allergosorbent test inhibition in dust extracts corresponding to dust from 0.1 m² of floor area and 0.01 m² of mattress area in 38 homes and 14 classrooms

	Homes		Schools	P values		
	Mattress (n = 19)	Living-room (n = 19)	Classroom (n = 14)	L vs M	M vs C	L vs C
Dog	12 ± 20 (0–84)	29 ± 30 (0–94)	9 ± 17 (0–57)	0.0001	n.s.	0.002
Birch	12 ± 11 (0–45)	12 ± 7 (3–30)	6 ± 3 (0–12)	n.s.	0.05	0.02
Timothy	1 ± 5 (0–24)	2 ± 2 (0–8)	1 ± 2 (0–6)	n.s.	n.s.	n.s.
Cladosporium	8 ± 13 (0–48)	10 ± 10 (0–47)	12 ± 7 (2–29)	n.s.	0.01	n.s.
Codfish	21 ± 13 (0–43)	37 ± 12 (16–67)	9 ± 7 (0–23)	0.0001	0.005	0.0001
Egg-white	3 ± 4 (0–19)	8 ± 8 (0–29)	2 ± 3 (0–8)	0.002	n.s.	0.02

Arithmetic mean ± S.D., range and P values are indicated (n.s., not significant); M, mattress; L, living-room, C, classroom.

these three mattresses no significant level of *Der p* I and *Der f* I were detected (Table 4). Two children in this group had an increased content of *Der p* I (30 ng/m²) in their mattresses without, however, demonstrating domestic mites microscopically (Table 4). All nine homes with increased *Der p* I levels had an AIH of ≥7.0 g/kg compared with 12 of 29 homes without increased *Der p* I levels ($P < 0.05$). In addition, when relating the detectable level of mite allergen to atopic symptoms an OR of 9.2 (95% CI: 1.3–82.6) was found.

Discussion

The concentration of *Der p* I and *Fel d* I in ng/m² of vacuumed area was chosen as it gives a better expression of the allergen exposure than by using the allergen contents in ng/g. This is due to the fact that the weight of vacuumed material per unit area in the homes and classrooms varied more than 200 fold and that sampling of very low dust concentrations from floors may give the impression of incorrect high allergen values when expressed in ng/g dust

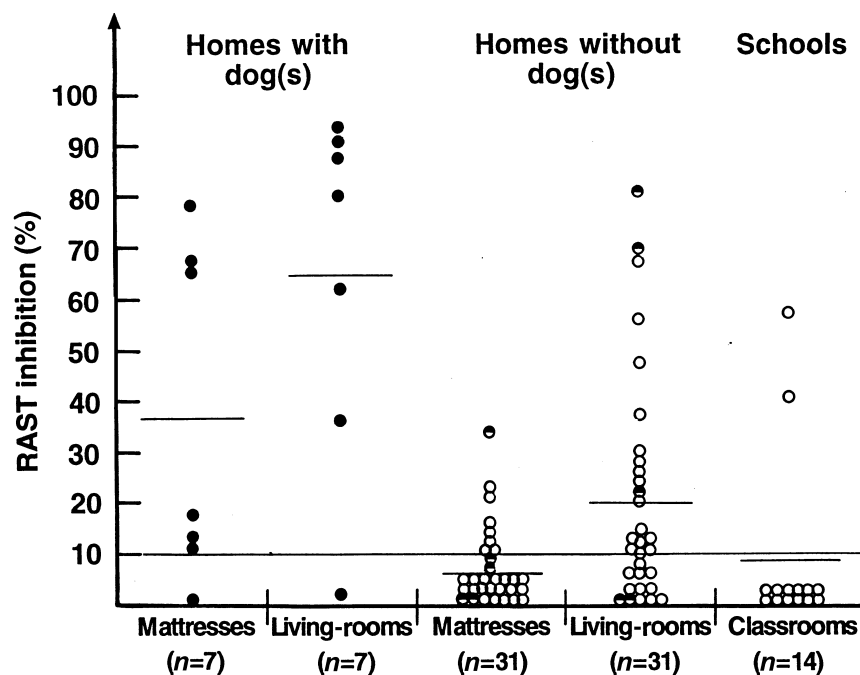


Fig. 1. Per cent radio-allergosorbent test inhibition of dog allergens in dust extract corresponding to dust from 0.1 m² floor area and 0.01 m² mattress area in 38 homes and 14 classrooms. Increased level(s) above solid horizontal line and mean antigen content (solid line) are also indicated. ●, homes with dog(s); ○, homes having previously kept dog(s); ○, homes without dog(s).

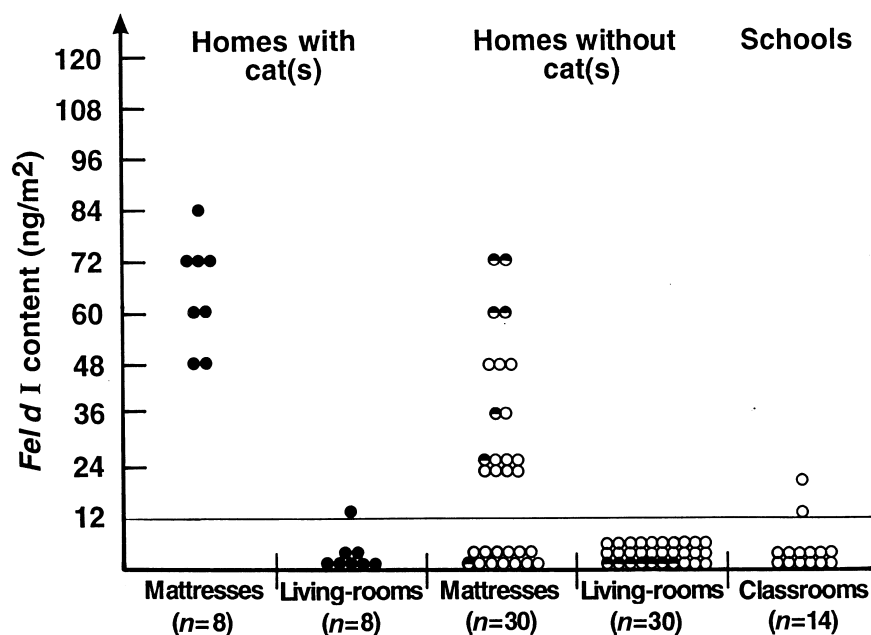


Fig. 2. Level of cat dander allergen *Fel d 1* in dust from 38 homes with or without cat(s) and in 14 classrooms. Increased level(s) above horizontal line. ●, homes with cat(s); ○, homes having previously kept cat(s); ○, homes without cat(s).

[24]. The vacuum cleaner model used in this investigation had good suction power, but the use of a filter with high retaining capacity may lead to a reduction in suction power and hence, lower amounts of removed dust, especially from the carpets [18,19,24]. Higher amounts of vacuumed material were found in homes of HDM-sensitized children than in the control group without, however, reaching statistical significance. The explanation for larger amounts of dust in the mattresses and living-rooms of HDM-sensitized children than in those of control children is unknown but may be due to accumulation caused by poor ventilation. Socio-economic factors such as poor cleaning, old floors and frequently used rooms may be of importance.

The quantity of dust found in mattresses was five times that found in living-rooms, probably reflecting larger dust reservoirs in the mattresses due to poor cleaning or vacuuming of the mattresses. On the other hand, the low amounts of dust from some of the living-rooms, and particularly from the classrooms, may reflect good cleaning procedures and/or smooth floors [7,18,19,24,26].

In Scandinavia furred pets are very common in families with both atopic and non-atopic members, indicating that children are often exposed to animal dander [14,19,27–29]. The highest amounts of dog allergens were found in the living-rooms of children with dogs, but high values were also found in mattresses of children keeping dogs. Interestingly, dog allergens were found both in the living-rooms and mattresses of children not keeping dogs and in several of the classrooms investigated. Significant amounts of cat allergens, on the other hand, were found only in mattresses, even in homes without cats. This may indicate that cats, as opposed to dogs, are often admitted to beds. These findings

indicate that most children were, in one way or another, exposed to animal dander, either by keeping dogs or cats, or by passive contact with pets. Moreover, these allergens can be brought to the children's homes on clothes, shoes, etc. or by visitors keeping pets. The absence of a significant relationship between direct exposure and sensitization may be due to several factors. Firstly, the sensitization to pets may occur due to known or unknown contact with pet antigens at home. Furthermore, the relationship between exposure to an allergen and subsequent development of sensitization and allergic diseases may vary between individuals and perhaps also in the same individual over time [27]. Secondly, it could be the result of external contact with pet antigens [28,30]. Our results indicate that sensitization to pets is not strictly related to environmental conditions at home. This possibility can be supported by a recent study where the total amount of cat allergen in classrooms was related to the number of teachers and students keeping cats at home [27]. Thus, sensitization to animal dander may be due to a ubiquitous presence of these allergens causing continuous exposure [18,19,24,27,29].

There was a good correlation between *Der p* I mite allergen content and *D. pteronyssinus* counted microscopically, as dust from seven of nine *D. pteronyssinus*-infested mattresses contained *Der p* I as detected by ELISA. Mite allergens were, however, also detected in dust samples from mattresses of two HDM-sensitized children whose mattresses were free of live mites. This disparity may be due to difficulties with the microscopy or that live mites will have avoided dry conditions and therefore left the surface of the mattresses [3–6]). Nevertheless, live mites may persist within the mattresses and continue to produce allergens that

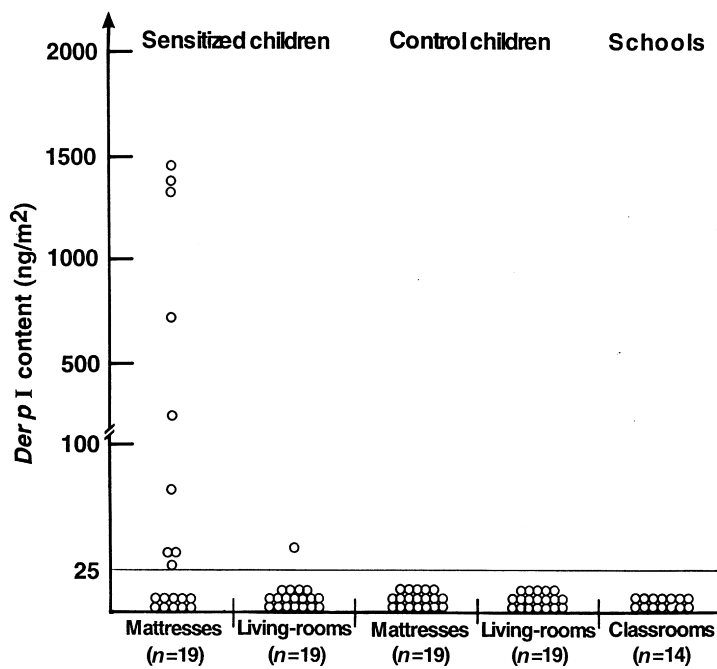


Fig. 3. The content of domestic mite allergen *Der p I* in dust from 38 homes of house dust mite-sensitized ($n = 19$) and control children ($n = 19$) and from 14 classrooms. Increased level(s) above horizontal line.

come to the surface, largely in the form of faecal pellets [3,5]. Interestingly, *Acarus siro*, a storage mite, was also demonstrated in the mattress of one HDM-sensitized child. This may suggest a certain degree of cross-allergenicity between storage mites and HDM or it may simply be explained by the fact that we accidentally did not detect any *D. pteronyssinus* [5,31].

A strong correlation was demonstrated between sensitization to HDM and the occurrence of *Der p I* allergens in mattresses and is in agreement with some previous findings [30,32], although considerably higher than others [6,33,34]. In addition, in our study HDM-sensitization occurred in children living in homes with low *Der p I* levels (50–75 ng/g dust). This corresponds to 10 mites/g dust [32] as opposed to previous suggestions of a threshold sensitization level of 2000 ng *Der p I* allergen/g dust (equivalent to 100 mites/g)

[4–6,8,33–36]. In fact, there was a clear correlation between mite exposure and atopic symptoms as seven of the nine exposed to *Der p I* had atopic symptoms compared to none of the 19 controls, which is in line with previous studies [3,34–36]. On the other hand, four children had no symptoms of atopy despite mite exposure and/or sensitization to HDM. These children may, however, still be at risk of developing symptoms later [17].

Der p I allergen was more prevalent in homes than in schools. *Der f I* allergen was virtually absent in homes and schools indicating that special indoor conditions may have favoured the growth of *D. pteronyssinus* [5,6,27,33,36]. A significantly higher mite allergen content was found in mattresses than in floor dust from living-rooms, which is in line with other reports [3,5,34]. The levels of *Der p I* and *Der f I* in the homes and schools investigated were low in

Table 4. *Der p I* allergen demonstration in relation to occurrence of *Dermatophagoides pteronyssinus* in mattresses of 38 schoolchildren from northern Norway

ELISA test	<i>Dermatophagoides pteronyssinus</i> identified by microscopy		<i>P</i> value
	Present	Absent	
<i>Der p</i> I allergen in mattresses			
Present	7	2	<0.0001
Absent	2	27	

contrast to more heavily mite-infested areas in Europe [1,4,5,31,33,34]. Data from homes of non-atopic children are similar to other Scandinavian investigations [6,19,35,36].

In our arctic area mite infestation is regarded as sparse or non-existent [4–6]. If the mites are dried out in winter, a period of higher humidity during the summer is still too short to permit their re-establishment [3,6,37]. Increased AIH appears to be a risk factor for mite growth and for sensitization to HDM. Thus, infestation of domestic mites may now be seen as a biological indicator of poor ventilation.

Schools harboured insignificant amounts of allergens compared with homes. Animal dander, which is perennial, and birch and timothy pollen, as seasonal allergens, are the most important allergens for the development of atopy in this area [10,14,21,27]. Food allergens, on the other hand, are suggested to be of little importance [21]. A RAST inhibition of 50% for none of the dust samples of *Cladosporium* confirm previous findings of low levels of aerospore counts in homes and schools [38]. Indoor smoking and other adjuvant factors, however, are reported to enhance sensitization and allergy symptoms [6,9–11,14,21], and may share the responsibility for the high occurrence of atopy in this area.

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