

Mite allergy and exposure to storage mites and house dust mites in farmers

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Summary

Sensitization to house dust mites, storage mites and other common inhalation allergens was studied in 144 farmers using SPT and RAST. The study population was selected from a random sample of 808 farmers and consisted of 47 persons who had declared themselves to suffer from asthma, 63 persons who had reported respiratory symptoms, and 34 healthy persons without respiratory symptoms. The most prevalent RAST was towards storage mites and was found in 17% of farmers who suffered from asthma and was estimated to occur in 5% of the random sample of farmers. A positive RAST to house dust mites was found in 17% of farmers who reported to suffer from asthma. Sensitization to pollens, animal dander and grain species was rare. A positive RAST to moulds was not found. There was a strong association between a positive RAST to house dust mites and a positive RAST to storage mites (odds ratio 21.0). A positive RAST to storage mites was significantly associated with living in a dwelling in the past which was recalled as damp (odds ratio 4.9). A high number of house dust mites was found in nearly all dwellings (median count 148 mites/0.1 g dust) and a high number of storage mites was found in some dwellings. This study suggests that in humid and temperate regions of Europe, allergy to storage mites in farmers is not caused exclusively by occupational exposure but damp housing conditions and indoor exposure to storage mites may also be important.

Clinical and Experimental Allergy, Vol. 20, pp. 211–219. Submitted 15 November 1988; second revision 6 October 1989; accepted 6 November 1989.

Introduction

Storage mites have optimum living conditions in humid and temperate environments [1]. They occur in large numbers in grain, hay, straw and dust in farm buildings [2–5]. Storage mites also constitute a part of the mite fauna in house dust in many countries [6]. Allergy to storage mites is common in patients with allergy to house dust mites and has been associated with occupational exposure and damp housing conditions [7]. In the late 1970's studies appeared [8] that showed a high prevalence of allergic asthma in farmers caused by allergy to storage mites. Bronchial provocation tests [9,10] have confirmed the specific role of storage mites as a cause of asthma in farmers. Subsequent studies [11–15] established the predominant role of storage mite allergy in farmers with allergy, although with a lower prevalence than in the

initial studies. It is characteristic that the studies came from regions in Northern Europe with a temperate and humid climate favourable for mite growth: the Orkney Islands [8], Scotland [11], England [14], the island of Gotland in the Baltic Sea [12], and Finland [13,15]. The purpose of this study was to assess the type and prevalence of sensitization towards possible occupational allergens in symptomatic and asymptomatic farmers, with special emphasis on sensitization towards storage mites.

Subjects and methods

Selection of study population

To obtain a high number of persons with respiratory symptoms and possible sensitization towards allergens, stratified sampling from symptomatic and asymptomatic farmers was used. From a cross-sectional study [16] of a representative sample of Danish farmers (1175 farmers),

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three samples were drawn from the farmers who had farmed exclusively for their living. In this population ($n=808$) the mean age was 52.9 yr, 35.3% were current smokers, 7.8% declared themselves to suffer from asthma, and 3.3% had medical treatment for asthma. From the 63 (7.8%) farmers who had declared themselves to suffer from asthma a random sample (group I) of 47 (75%) persons was taken. From the 228 (28.2%) farmers who had reported respiratory symptoms, such as shortness of breath and wheezing or dry cough, a random sample (group II) of 63 (28%) persons was taken. From the 517 (64%) farmers who reported not to suffer from asthma and without respiratory symptoms a random sample (group III) of 34 (7%) persons was taken. Characteristics of the study population are given in Table 1.

Allergological investigation

The allergological evaluation was established with a structured interview which also contained questions about housing conditions and family history. Atopic relatives in this study means one or more first-degree relatives with asthma, hay fever or eczema. Clinical evaluation comprised measurement of forced expiratory volume in 1 second (FEV_1) and other lung function measurements, including measurement of airways reactivity by histamine challenge. These results have been published elsewhere [17]. Skin-prick test (SPT) was performed with the Pricklancet needle (Dome/Hollister-Stier, Studley, U.K.). Allergen preparations were Soluprick allergen solutions (ALK, Copenhagen, Denmark) except storage mites which were Diepdiagnost (Diephuis, Groningen, The Netherlands).

Positive control was histamine (1 mg/ml) and negative

control was glycerol-buffered diluent (ALK). The following allergen extracts were used: birch pollen (*Betula verrucosa*), timothy pollen (*Phleum pratense*), mugwort pollen (*Artemisia vulgaris*), horse, dog, and cat dander, house dust mites (*Dermatophagoides farinae* and *D. pteronyssinus*) which all had a strength of three histamine-equivalent pricks (HEP) [18]. Extracts of storage mites (*Acarus siro*, *Tyrophagus putrescentiae*, and *Lepidoglyphus destructor*) had a strength of 1% (w/v) and were reconstituted to 0.1% (w/v) in Pharmacia albumin diluent (Pharmacia, Uppsala, Sweden). Extracts of cow dander, swine epithelium, fungi and grain pollens were used in a strength of 5% (w/v). Mould species were *Alternaria alternata*, *Cladosporium herbarum* and *Aspergillus fumigatus*. Grain species were rye (*Secale secale*), oat (*Avena sativa*), wheat (*Triticum sativum*), and barley (*Hordeum sativum*). Specific IgE in serum was measured with the radio-allergosorbent test (RAST) (Pharmacia). All persons were measured for specific IgE for house dust mites, storage mites, grain, moulds, cow and swine dander. For pollen, horse, dog, and cat dander a RAST was performed when there was a positive SPT towards the allergen.

In this study a positive SPT is defined as a weal ≥ 2 mm in diameter and a positive RAST is defined as ≥ 0.35 PRU/ml.

Evaluation of housing conditions

Housing conditions were assessed by a questionnaire with special emphasis on damp housing conditions. Questions were asked for the presence of visible growth of mould in the present or past dwelling and the presence of damp basements. Questions were asked concerning energy preserving measures such as replacement of single glass

Table 1. Characteristics of three groups of farmers in the study population. See methods section for definitions

	Group I ($n=47$)	Group II ($n=63$)	Group III ($n=34$)
Mean age (yr)	61	53	55
Current smokers (%)	38	51	28
Shortness of breath (%)	70	31	0
Wheezing (%)	76	40	0
Dry cough (%)	54	69	0
Medical treatment for asthma (%)	50	5	0
Atopic relatives (%)	50	32	17
Mould growth in dwelling (%)	21	33	35
Damp housing in the past (%)	57	54	56
Sealing of dwelling (%)	75	94	91

windows in leaky frames with double-glazing in airtight frames which reduces natural ventilation and increases humidity in dwellings [19]. This is referred to as sealing of the dwelling.

Sampling and analysis of mites

Mite exposure in homes was assessed by a standardized sampling and analysis of dust from mattresses [20]. Samples of dust from mattresses were taken by the farmers with a vacuum cleaner. After staining, dead and living mites were counted with a stereo microscope and mite counts were expressed as the number of mites/0.1 g of dust. Mites were classified as either house dust mites or storage mites. Because of seasonal variation in house dust mites, all persons studied in October and November took new samples of house dust in February and mite counts were defined as the average of the two samples. Samples of grain, straw and hay were taken by the farmers themselves on the day they came for clinical investigation. Samples of 50–100 g were taken from the materials used that day at the farm and placed in separate airtight plastic bags. The samples were processed the following day with the Berlese method [21] and the number of living mites counted and expressed as number of living mites/kg of material. Mites were counted with a stereo microscope at $\times 30$ magnification. For identification of mites the guidelines from Hughes [22] were used. The study took place from October 1985 to February 1986.

Statistical evaluation

Frequencies of discrete variables were compared with a chi-square test. Association between dichotomous variables in two-way tables was assessed by the odds ratio [23] which is an estimation of the relative risk. Confidence limits for odds ratios was according to Miettinen [24]. Stratified analysis, according to Mantel and Haenszel [25], was used to evaluate confounding effects between variables. Significance values are 5% and confidence limits are 95% when no other values are given.

Ethics

The study was approved by the ethics committee of Aarhus County and conducted in accordance with the Helsinki declaration.

Results

Frequencies of SPT and RAST

The majority of positive SPT and RAST to the tested allergens was found in group I whereas almost no positive

reactions were found in group III (Table 2). The other characteristic feature was the predominance of sensitization to storage mites and house dust mites compared to other allergens. In group I, 10 of 47 (21%), in group II, five of 63 (8%), and in group III, one of 34 (3%) had a positive SPT to storage mites. Extrapolation to the total population of farmers ($n=808$) from which the samples of farmers were drawn suggests that 5.8% of farmers had a positive SPT to storage mites. In the same way it was estimated that 4.6% of all farmers ($n=808$) had a positive RAST to storage mites. In group I, five of 47 (11%) persons had a positive SPT to house dust mites and eight of 47 (17%) a positive RAST to house dust mites. When the frequencies of sensitization to house dust mites was extrapolated to the total population of farmers ($n=808$) it was estimated that 3.5% of farmers had a positive SPT and 5.9% a positive RAST to house dust mite.

For house dust mites (*D. farinae* and *D. pteronyssinus*) nearly all sensitized persons had a positive SPT and RAST to both species. For storage mites, SPT to *A. siro* was predominant, for 14 of 16 (88%) sensitized persons, whereas a positive RAST to *L. destructor* was most frequent, for 10 of 12 (83%) sensitized persons. A positive RAST to any grain species occurred in five persons (three in group I and two in group II). A positive RAST to cow dander was found in three persons in group I and a positive RAST to swine epithelium was found in two persons in group I (both RAST 0.35–0.70 PRU/ml in two persons with clinical asthma and multiple sensitization to pollens, grain species, house dust mites and storage mites). Only one person had a positive RAST to pollen (timothy and mugwort) and a positive RAST to moulds was not found.

Association between sensitization to mites and other variables

The association between SPT and RAST to storage mites and house dust mites and other variables was examined in two-way tables (Tables 3 and 4).

The most prominent feature was the very strong association between sensitization to storage mites and house dust mites, both with respect to SPT (odds ratio 127.0) and RAST (odds ratio 21.0). This meant that 50% of farmers with a positive RAST to house dust mites also had a positive RAST to storage mites, whereas the prevalence was only 4.6% among farmers with a negative RAST to house dust mites. For farmers with a positive SPT to house dust mites, 89% had a positive SPT to storage mites whereas the frequency was only 5.9% among farmers with a negative SPT to house dust mites.

A positive SPT and RAST to house dust mites was significantly associated with the presence of atopic

Table 2. Number of positive skin-prick tests (SPT) with a weal ≥ 2 mm in diameter and number of positive RAST (≥ 0.35 PRU/l) in three groups of farmers. A RAST for pollen, horse, dog, and cat dander was only performed when there was a positive SPT

	Group I (n=47)		Group II (n=63)		Group III (n=34)	
	SPT	RAST	SPT	RAST	SPT	RAST
Pollens						
Timothy (<i>P. pratense</i>)	6	1	4	0	0	0
Mugwort (<i>A. vulgaris</i>)	4	1	2	0	1	0
Birch (<i>B. verrucosa</i>)	3	0	2	0	0	0
Any pollen	7	1	4	0	0	0
Animals						
Horse	1	0	2	0	0	0
Dog	2	0	1	0	0	0
Cat	1	0	1	0	0	0
Cow	4	3	1	0	0	0
Swine	1	2	1	0	0	0
Cow or swine	5	4	2	0	0	0
House dust mites						
<i>D. pteronyssinus</i>	4	7	2	2	1	1
<i>D. farinae</i>	4	7	3	2	0	2
Any house dust mite	5	8	3	2	1	2
Storage mites						
<i>A. siro</i>	10	2	4	2	0	1
<i>T. putrescentiae</i>	8	4	5	0	0	1
<i>L. destructor</i>	4	8	4	1	1	1
Any storage mite	10	8	5	3	1	1
Grain						
Rye (<i>S. secale</i>)	3	1	1	2	0	0
Oat (<i>A. sativa</i>)	3	3	1	1	0	0
Wheat (<i>T. sativum</i>)	3	2	1	1	0	0
Barley (<i>H. sativum</i>)	3	3	2	0	0	0
Any grain	3	3	2	2	0	0
Moulds						
<i>A. alternaria</i>	0	0	1	0	0	0
<i>C. herbarum</i>	1	0	1	0	0	0
<i>A. fumigatus</i>	1	0	1	0	0	0
Any mould	1	0	1	0	0	0

relatives, odds ratios 5.0 and 5.3, respectively, whereas sensitization to storage mites was not significantly associated with the presence of atopic relatives. A positive SPT to storage mites and house dust mites and a positive RAST to house dust mites was not significantly associated with indicators of damp housing conditions. A positive RAST to storage mites was significantly associated with damp housing conditions in the past (odds

ratio 4.9) but not with mould growth in the present dwelling, or sealing of the dwelling.

Smoking was not significant as a risk factor for a positive RAST to storage mites (odds ratio 3.2) but it was associated with mould growth in the present dwelling (odds ratio 2.2) and damp housing conditions in the past (odds ratio 1.7), so a stratified analysis was performed. The relationship between a SPT and RAST to house dust

Table 3. Associations between a positive SPT (≥ 2 mm) for house dust mites, and storage mites and possible risk factors for sensitization to mites

	Storage mites (n=16)	Atopic relatives (n=44)	Mould growth (n=42)	Past damp housing (n=77)	Sealing (n=124)	Smoking (n=59)
House dust mites (n=9)	127.0 36.6-440.0	5.0 1.3-19.0	2.0 0.5-7.9	3.3 0.7-15.0	<i>P</i> =0.23	0.7 0.2-3.0
Storage mites (n=16)		2.5 0.9-7.1	1.5 0.5-4.5	2.1 0.7-6.2	1.1 0.2-5.1	1.1 0.4-3.3
Atopic relatives (n=44)			1.2 0.5-2.6	0.6 0.3-1.3	0.7 0.2-1.9	0.8 0.5-1.3
Mould growth in present dwelling (n=42)				n.d.	1.2 0.6-2.6	2.2 1.1-4.6
Damp housing in the past (n=77)					n.d.	1.7 0.9-3.3
Sealing of dwelling (n=124)						0.6 0.2-1.5

Values are odds ratios and 95% confidence limits for odds ratios. If 1.0 is enclosed within the confidence interval the association between the two variables is not significant ($P > 0.05$). If an odds ratio could not be determined (one marginal in the two-way table was 0) the significance from the chi-square test is indicated. The number of persons positive in each category is shown in parentheses.

mites and mould growth in the present dwelling and damp housing in the past was examined in two-way tables with stratification for smoking (Mantel Haenszel test) but none of the odds ratios changed significantly and achieved or lost significance. The association between a positive RAST to storage mites and damp housing in the past (odds ratio 4.9, 1.2-20.3) was changed to 4.1 (1.0-17.1) after stratification for smoking.

In the same way the relationship between a positive RAST to storage mites and smoking was examined with stratification for mould growth in the present dwelling (new odds ratio 3.0, 0.9-10.5) and damp housing in the past (new odds ratio 2.7, 0.8-8.9). The association between smoking and a positive RAST to storage mites thus decreased with stratification for indicators of damp housing conditions. Sealing of the dwelling was not significantly associated with SPT or RAST to storage mites and house dust mites.

Mite counts in dwellings

One hundred and five of 143 persons delivered samples of house dust from mattresses for analysis. There was no

significant difference in the percentage of persons who delivered samples in groups I-III (74%, 71%, 68%). For the 105 persons who delivered samples of house dust, the percentages of persons in groups I-III with mould growth in the dwelling (17%, 36%, 30%), damp housing in the past (51%, 56%, 52%) and sealing of the dwelling (77%, 89%, 91%) were not significantly different from the frequencies for all persons in groups I-III (Table 1).

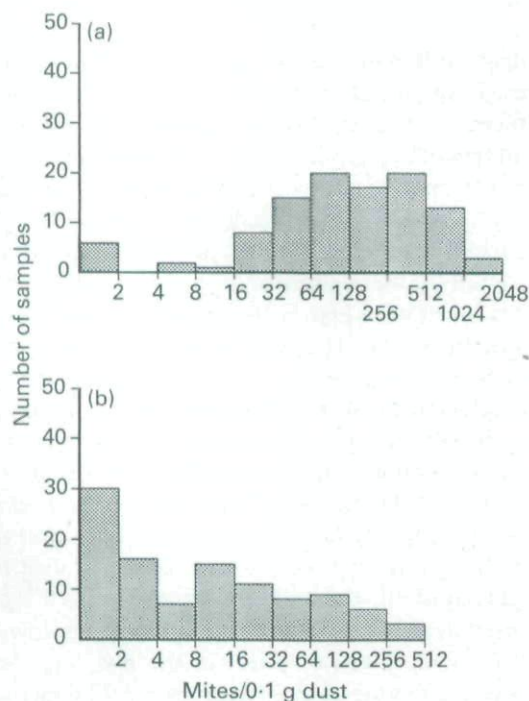
Mite counts were high with regard to house dust mites and storage mites. The distribution of mite counts is shown in Fig. 1. The distribution of house dust mite counts seemed to follow a log-normal distribution whereas the distribution of storage mite counts was skewed towards zero on a logarithmic scale. The 50% and 90% percentile was 148 and 639 mites/0.1 g dust for house dust mites and 6 and 122 mites/0.1 g dust for storage mites.

In a chi-square test, 10, 100 and 300 house dust mites/0.1 g dust and 10, 100 and 200 storage mites/0.1 g dust were used as arbitrary cut-off values between low, high and very high values of mites in the dwelling. In chi-square test with mite counts (given by the different cut-off values) and indicators (yes/no) of mould growth in the dwelling and sealing of the dwelling no significant

Table 4. Associations between a positive RAST (≥ 0.35 PRU/l) for house dust mites and storage mites and possible risk factors for sensitization to mites

	Storage mites (n=12)	Atopic relatives (n=44)	Mould growth (n=42)	Past damp housing (n=77)	Sealing (n=124)	Smoking (n=59)
House dust mites (n=12)	21.0 7.0-63.0	5.3 1.7-16.9	0.8 0.2-3.1	2.8 0.8-10.4	$P=0.16$	1.5 0.5-4.9
Storage mites (n=12)		2.4 0.7-7.9	1.8 0.5-6.1	4.9 1.2-20.3	1.8 0.2-14.1	3.2 0.9-10.0
Atopic relatives (n=44)			1.2 0.5-2.6	0.6 0.3-1.3	0.7 0.2-1.9	0.8 0.5-1.3
Mould growth in present dwelling (n=42)				n.d.	1.2 0.6-2.6	2.2 1.1-4.6
Damp housing in the past (n=77)					n.d.	1.7 0.9-3.3
Sealing of dwelling (n=124)						0.6 0.2-1.5

Values are odds ratios and 95% confidence limits for odds ratios. If 1.0 is enclosed within the confidence interval the association between the two variables is not significant ($P > 0.05$). If an odds ratio could not be determined (one marginal in the two-way table was 0) the significance from the chi-square test is indicated. The number of persons positive in each category is shown in parentheses.

**Fig. 1.** Distribution of (a) house dust mite and (b) storage mite counts in dust samples from mattresses in 105 farmhouses.

association was found ($P > 0.05$). In the same way the relationship between mite counts in the dwellings and the presence of a positive RAST towards house dust mites and storage mites was examined and no significant association was found ($P > 0.05$).

Mite counts in crops

A total of 117 farmers delivered samples of grain (98 samples), straw (116 samples) and hay (48 samples) for analysis of mites. There was no significant difference in groups I-III with respect to the percentage of farmers (79%, 86%, 76%) who delivered these samples. The number and distribution of mites is shown in Table 5. Hay samples had 10 times as many mites as grain samples and three times as many mites as samples of straw. The distribution of genera differed somewhat between materials, as *L. destructor* was dominant in grain and straw and *A. siro* was dominant in hay. Living mites were found in nearly all samples (88.8-97.9%). The predominant genera of storage mites in grain, straw and hay were therefore identical to the genera to which the farmers had been tested by SPT and RAST.

Table 5. Mean number of living mites/kg in three materials, and percentage of samples with living mites in three materials

	Concentration of living mites/kg			Per cent samples with living mites		
	Grain	Straw	Hay	Grain	Straw	Hay
Species						
<i>Lepidoglyphus</i>	1838	5713	2746	85.7	67.2	66.7
<i>Acarus</i>	3038	4645	27 075	70.4	47.4	68.8
<i>Tyrophagus</i>	857	4432	10 247	42.9	50.9	54.2
<i>Tarsonemus</i>	167	1628	8593	34.7	28.4	60.4
<i>Tydeus</i>	61	276	1222	22.4	22.4	41.7
<i>Cheyletus</i>	237	69	910	40.8	9.5	31.3
Others	19	205	55	14.3	12.1	12.5
All mites	6217	16 968	50 848	92.9	88.8	97.9
Number of samples	98	116	48	98	116	48

Discussion

The prevalence and type of sensitization in this study is in agreement with the large survey of Swedish farmers [12] and the survey of Finnish farmers [13] which showed that *L. destructor* was the most important genus causing allergy to storage mites in Nordic farmers. Similar results have been obtained in Scotland [8] and England [14].

The high number of living mites in grain, straw and hay and the predominance of *L. destructor* is also in agreement with other surveys of storage mites in farming environments [2,4]. The fluctuation of mite counts with the length of storage time and the subsequent lack of association between sensitization to storage mites and mite counts in crops was demonstrated in a Scottish study from 1984 [8].

It is remarkable that very few farmers were sensitized to pollens and animal dander although they have a high exposure to these allergens. This study did not include a group of persons complaining specifically of rhinoconjunctivitis as in a Swedish survey [12] where the highest prevalence of sensitization to pollens was found in this group of farmers. Another possible explanation for this observation is that persons with obvious allergy to pollen or animal dander during childhood or youth might not enter farming or would leave farming at an early age. No data are available to assess this selection bias in this cross-sectional study. The mean age in the group of farmers from which the study population was taken was 53 yr and the number of positive SPT to common environmental allergens has been demonstrated to decrease with age [26]; the Swedish survey [12] included a large number of people aged 16–35 yr. There was a strong association between allergy to house dust mites and

allergy to storage mites in farmers. This was unlikely to be caused by crossreactions between the two mite genera because analysis of SPT [7,27], RAST [28], RAST inhibition [28] and crossed immunoelectrophoresis [29] have demonstrated that the two mite species are not allergenically related. Allergy to house dust mites was associated with an atopic family history whereas allergy to storage mites was not. This points to a strong environmental factor as the common cause of allergy to house dust mites and storage mites. This study points towards the possibility that damp housing conditions and mite exposure in farm houses could be the common environmental factor for sensitization to house dust mites and storage mites. Farmers who recalled living in dwellings which were 'damp' had increased risk of having allergy to house dust mites and storage mites, whereas the presence of visible mould growth in their present dwelling had no association with mite allergy. This apparent paradox might be explained by the age and size of the farmhouses in this study. Most of the houses were 70–100 years old and often had 12–14 rooms. It is therefore common today that only part of the house is used for living and that unused rooms are not heated because of high costs. The presence of visible mould growth might therefore not be related to the level of indoor humidity. The findings in this study are in agreement with earlier studies that stressed the importance of damp housing conditions for the development of allergy to storage mites. Wraith *et al.* [7] found an association between dampness in the dwelling and a positive skin-prick test to storage mites. A refined statistical analysis [30] showed that the two main factors associated with allergy to storage mites were occupational exposure and excessively damp housing. Very high numbers of mites were found in

the farmhouses in this study, suggesting damp housing conditions. A study of Danish flats has demonstrated that sealing of the dwelling caused an increase in indoor humidity followed by increased growth of mites [19] but in the present study the majority (Table 1) had sealing of the dwelling so an association with sensitization to house dust mites would be difficult to detect.

Internationally, a concentration of 10 mites/0.1 g of house dust has been proposed as a limit above which there is increased risk of sensitization to house dust mites and increased risk of asthma symptoms in mite-allergic individuals [31]. As 95% of farmers in this study had mite counts in their dwellings above 10/0.1 g dust, this uniform high exposure might explain the lack of association between mite counts and a positive SPT and RAST to house dust mites. Cuthbert *et al.* [11] found high mite counts in Orkney farm houses but no details of housing was given in that study. In English farmers [14] as well as in the Swedish farmers in Gotland [12] there was a strong association between allergy to house dust mites and allergy to storage mites. This constitutes indirect evidence that a common cause of allergy to house dust mites and storage mites might also be found in farmers in Sweden and England, with humid temperate climate, as in Denmark, favourable for mite growth in dwellings. The relationship between housing conditions and allergy to storage mites is probably different in regions with other climatic conditions and the conclusions from this study are only valid for regions in Northern Europe with a temperate and humid climate. We failed to demonstrate any significant association between allergy to storage mites and a present damp dwelling. This study was not a case control study of damp housing conditions and allergy to storage mites and the questions used to evaluate dampness in the present dwelling were not able to discriminate between damp and dry dwellings. The fact that farmers may be exposed to storage mites in their dwellings should be considered when farmers with allergy to storage mites are encountered. Farmers with allergy to house dust mites should be tested for allergy to storage mites and vice versa. Allergy to storage mites in farmers is not caused exclusively by occupational exposure but damp housing conditions seem to be important. This has implications for advice given to farmers, for treatment of allergic farmers and for future prophylaxis.

Acknowledgment

This study was supported by Sygekassernes Helsefond, Copenhagen, Denmark.

References

- 1 Cunnington AM. The effect of physical conditions on the development and increase of some important storage mites. *Ann Appl Biol* 1976; 82:175–8.
- 2 Griffith DA, Wilkin DR, Southgate BJ, Lynch SM. A survey of mites in bulk grain stored on farms in England and Wales. *Ann Appl Biol* 1976; 82:180–4.
- 3 Terho EO, Leskinen L, Husman K, Karenlampi L. Occurrence of storage mites in Finnish farming environments. *Allergy* 1982; 37:15–19.
- 4 Leskinen L, Klen T. Storage mites in the work environment of farmers. *Eur J Respir Dis* 1987; 71(suppl 152):101–11.
- 5 Hallas T. Mites in hay stored in Iceland. *J Agric Res Icel* 1981; 13:61–7.
- 6 Bronswijk JEMH. House dust biology. Zeist, The Netherlands: NIB Publishers, 1981.
- 7 Wraith DG, Cunnington AM, Seymour WM. The role and allergenic importance of storage mites in house dust and other environments. *Clin Allergy* 1979; 9:545–61.
- 8 Cuthbert OD, Brostoff J, Wraith DG, Brighton WD. 'Barn allergy': asthma and rhinitis due to storage mites. *Clin Allergy* 1979; 9:229–36.
- 9 Ingram CG, Jeffrey IG, Symington IS, Cuthbert OD. Bronchial provocation studies in farmers allergic to storage mites. *Lancet* 1979; ii:1330–2.
- 10 van Hage-Hamsten M, Ihre E, Zetterström O, Johansson SGO. Bronchial provocation studies in farmers with positive RAST to the storage mite *Lepidoglyphus destructor*. *Allergy* 1988; 43:545–51.
- 11 Cuthbert OD, Jeffrey IG, McNeill HB, Wood J, Topping MD. Barn allergy among Scottish farmers. *Clin Allergy* 1984; 14:197–206.
- 12 van Hage-Hamsten M, Johansson SGO, Zetterström O. Predominance of mite allergy over allergy to pollens and animal danders in a farming population. *Clin Allergy* 1987; 17:417–23.
- 13 Terho EO, Vohlonen I, Husman K, Rautalahti M, Tukiainen H, Viander M. Sensitization to storage mites and other work-related and common allergens among Finnish dairy farmers. *Eur J Respir Dis* 1987; 71(suppl 152):165–74.
- 14 Blainey AD, Topping MD, Ollier S, Davies RJ. Respiratory symptoms in farm workers: role of storage mites. *Thorax* 1988; 43:697–702.
- 15 Terho EO, Husman K, Vohlonen I, Rautalahti M, Tukiainen H. Allergy to storage mites or cow dander as a cause of rhinitis among Finnish dairy farmers. *Allergy* 1985; 40:23–6.
- 16 Iversen M, Dahl R, Korsgaard J, Hallas T, Jensen EJ. Respiratory symptoms in Danish farmers: an epidemiological study of risk factors. *Thorax* 1988; 43:872–7.
- 17 Iversen M, Dahl R, Jensen EJ, Korsgaard J, Hallas T. Lung function and bronchial reactivity in farmers. *Thorax* 1989; 44:645–9.
- 18 Aas K, Backman A, Belin L, Weeke B. Standardization of allergen extracts with appropriate methods. *Allergy* 1978; 33:130–7.

- 19 Korsgaard J. Indoor climate in Danish flats. Report No. 1, The National Board of Health, Copenhagen. 1981.
- 20 Korsgaard J, Hallas TE. Tarsenomid mites in Danish house-dust. *Allergy* 1979; 34:225-32.
- 21 Haarlov N. A new modification of the Tullgren apparatus. *J Animal Ecol* 1947; 16:115-21.
- 22 Hughes AM. Mites of stored food and houses. *Min Agric Fish Food Tech Bull* 1976; 9:1-400.
- 23 Breslow NE, Day NE. Statistical methods in cancer research, Volume 1. The analysis of case-control studies. Lyon: IARC publication No. 32, 1980.
- 24 Miettinen OS. Simple interval estimation of risk ratio. *Am J Epidemiol* 1974; 100:515-16.
- 25 Mantel N, Haenszel W. Statistical aspects of the analysis of data from retrospective studies of disease. *J Nat Cancer Inst* 1959; 22:719-48.
- 26 Barbee RA, Kaltenborn W, Lebowitz MD, Burrows B. Longitudinal change in allergen skin test reactivity in a community population sample. *J Allergy Clin Immunol* 1987; 79:16-24.
- 27 Korsgaard J, Dahl R, Iversen M, Hallas T. Storage mites as a cause of bronchial asthma in Denmark. *Allergol Immunopathol* 1985; 13:143-9.
- 28 van Hage-Hamsten M, Johansson SGO, Johansson E, Wirén A. Lack of allergenic cross-reactivity between storage mites and *Dermatophagoides pteronyssinus*. *Clin Allergy* 1987; 17:23-31.
- 29 Arlien LG, Geis DP, Vyzenski-Moher DL, Bernstein IL, Gallagher JS. Cross antigenic and allergenic properties of the house dust mite *Dermatophagoides farinae* and the storage mite *Tyrophagus putrescentiae*. *J Allergy Clin Immunol* 1984; 74:172-9.
- 30 Agha M, Gnanasakthy A. A cluster analysis of the effects of storage mites as allergens in relation to certain occupations and living conditions. *Clin Allergy* 1981; 11:499-504.
- 31 Platts-Mills TAE, de Weck AL. Dust mite allergens and asthma. A worldwide problem. *J Allergy Clin Immunol* 1989; 83:416-27.

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