

Storage mite allergy among grain elevator workers

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A total of 139 workers (71 % of the available work force) in four grain elevator stores in Aalborg, Denmark, participated in a cross-sectional study on the prevalence of storage mite allergy among grain elevator workers. All underwent interview, prick test with a standard panel of allergens and the storage mites *Acarus siro*, *Lepidoglyphus destructor* and *Tyrophagus putrescentiae*, RAST to the three above-mentioned storage mites plus *Glycyphagus domesticus* and wheat, measurement of serum total IgE, and spirometry. Pulmonary symptoms were present among 44 %, nasal and eye symptoms among 48 %. Thirty-one per cent complained of work-related respiratory symptoms. Fourteen per cent of these workers had only nasal symptoms. Comparing the prick test result and the history, 6.4 % had respiratory storage mite allergy, while 15.9 % were sensitized to storage mites. Storage mites seem to be the most important allergen among grain elevator workers in Denmark. Faunistic examination of samples of grain and dust showed that storage mites, in particular *A. siro*, *L. destructor* and *T. longior*, were found in 73 % of grain samples, while all dust samples contained mites.

Key words: grain elevator workers; respiratory allergy; storage mites.

Accepted for publication 12 January 1987

Acute and chronic respiratory symptoms among North American grain elevator workers are common (16). In addition, the bronchial reactivity among non-smoking grain elevator workers is shown to be higher compared to a control group (11). It has been proposed that grain dust can cause air-flow obstruction in two ways: by inducing asthma and by inducing chronic bronchitis (6).

Several constituents in grain dust are suspected of causing the respiratory symptoms. Grain dust is a complex material containing various types of grain and their disintegration products, pollens, fungi, insects, mites and silica. It may be contaminated with pesticides and excretes from rodents and birds (2). Skin prick test with non-standardized extracts of crude grain dust have given varying prevalences of positive prick test from 0 % (5) to 18 % (15).

Recently, allergy to storage mites, comprising the genera *Acarus*, *Lepidoglyphus*, *Tyrophagus* and *Glycyphagus* has been shown among farmers

(7, 8, 13). Preliminary results have indicated that storage mites might also be of importance in a related occupation: the grain elevator industry (4).

The purpose of the present study was to evaluate the prevalence of storage mite allergy among workers in the Danish grain-elevator industry.

MATERIAL AND METHODS

A total of 139 workers (71 % of the available work force), all males, in four grain elevator stores in Aalborg, Denmark, participated. Most of the workers (69 %) were grain elevator operators, 14 % were craftsmen, 12 % were truck-drivers and 5 % had other functions. The median age was 44 years (95 % Inter-Percentile Range (IPR): 24-60.5 years) and the median duration of employment 11 years (95 IPR: 0-35.5 years). Smoking habits were: 61 % smokers, 20 % ex-smokers (previously smoked > 1 year) and 19 % non-smokers.

The survey took place between February 13 and March 26, 1985. All participants were examined at the Chest Clinic, Aalborg Hospital. All subjects were interviewed on their environment and health by one of the authors using a modified edition of a questionnaire on allergy commonly used in Denmark (9). Work-related symptoms were considered present when they were “brought on or aggravated by exposure to dust at work” and when they occurred at least several days a month.

Skin tests were carried out as prick test with a standard panel of allergen extracts (birch, timothy and mugwort pollen, horse, dog and cat dander, *Dermatophagoides pteronyssinus*, *Alternaria tenuis* and *Cladosporium herbarum*) in the concentration 10 HEP (Pharmacia Spectralgen®, Pharmedgen®) and aqueous extracts of the storage mites *Acarus siro*, *Lepidoglyphus destructor* and *Tyrophagus putrescentiae* in concentrations 1,000 Noon Equivalents per ml (NE/ml) and 10,000 NE/ml (laboratorium Diephuis, Diepdiagnost®). Only the last 94 participants were tested with the strong extracts of storage mites. As positive controls, histamine 10 mg/ml was used for the standard panel and histamine 1 mg/ml for the extracts of storage mites (1).

Serum IgE antibodies directed against the three above-mentioned storage mite species, *Glycyphagus domesticus* and wheat were measured by RAST (Pharmacia Phadebas, range 0 to 4). Serum total IgE was measured by Phadebas IgE PRIST. A serum IgE value above 122 U/ml was considered strongly suggestive of an allergic disease (20).

Forced expiratory volume in 1 s (FEV₁), vital capacity (VC) and forced vital capacity (FVC) were measured on a 8 l Vitalograph 20.400 S dry wedge spirometer before and after inhalation of three doses of salbutamol (Salbuvent®) 0.1 mg/dose. VC was recorded before inhalation of salbutamol. All volumes were corrected to BTPS (10).

Abnormal pulmonary function tests were present with a value less than 1.64 Residual Standard Deviation below the predicted value (17).

To estimate the occupational exposure to

storage mites, samples of grain and grain dust were investigated. Seventy-two samples (450–2,500 g) were taken from 62 different grain lots coming in to the four grain elevator stores during March and April 1985. Further, 18 samples of dust (2–27 g) from transport works, silo ceiling and ventilation systems were taken. Mite numbers in these samples were estimated by Th. E. Hallas and Jens Korsgaard as described in (14).

Statistics

In the description of data we used median and 95 IPR for data on ratio-interval scale or frequencies and 95 % confidence level for data on nominal scale.

In comparison of frequencies we used Chi-square test for unpaired data and McNemar test for paired data. All calculations were performed on an SPSS-programme.

RESULTS

Prevalence of symptoms

Pulmonary symptoms were rather frequent among the grain elevator workers (Table 1). For the whole sample, irrespective of smoking habits, dyspnea was reported by 15 %, wheezing by 20 % cough by 17 %, expectoration by 13 % and chest

Table 1
Prevalence of pulmonary symptoms among 139 grain elevator workers

	All symptoms		Most annoying symptom ¹	
	n	%	n	%
Wheezing	28	20.1	8	14.3
Cough	24	17.3	19	33.9
Chest tightness	15	10.8	7	12.5
Dyspnea	21	15.1	15	26.8
Expectoration	18	12.9	6	10.7
Chronic bronchitis	15	10.8	–	–
No pulmonary symptoms	78	56.1		

¹ The numbers shown for 56 persons who could graduate their pulmonary symptoms.

tightness by 11 %. Eleven per cent confirmed that they had had daily expectoration for more than 3 months each year in later years. In total 44 % had pulmonary symptoms. Most symptomatic participants (59 %) experienced their symptoms daily or several days a week, while 16 % were troubled a few days per month. The remainder (25 %) had only one or more episodes of pulmonary symptoms per year. Most (57 %) of the symptomatic persons felt that dust including grain dust aggravated their lung symptoms.

Nasal and eye symptoms were as frequent as pulmonary symptoms. Twenty-three per cent complained of conjunctival itching, 24 % of sneezing (more than 3 sneezes per bout), 24 % of rhinitis and 21 % of nasal tightness (Table 2). In total, 48 % had nose and eye symptoms. The majority of complainers (64 %) mentioned dust including grain dust as an aggravating factor. Approximately half (34/66) of the persons with nasal and eye symptoms also complained of pulmonary symptoms. Of skin symptoms, eczema was the most frequent (7 %) and urticaria the least frequent (1 %). Fourteen per cent complained of other skin symptoms.

Thirty-seven (27 %) had none of the above-mentioned symptoms.

Thirty-one per cent (95 % confidence limits: 23 %-39 %) complained of work-related respiratory symptoms (excluding cough and expectoration) including 14 % who had only nasal symp-

Table 2
Prevalence of nasal and eye symptoms among 139 grain elevator workers

	All symptoms		Most annoying symptom ¹	
	<i>n</i>	%	<i>n</i>	%
Sneezing	33	23.7	13	23.6
Rhinitis	33	23.7	13	23.6
Eye itching	32	23.0	17	30.9
Nasal tightness	29	20.9	9	16.4
Sinusitis	3	2.2	2	3.6
No sense of smell	2	1.4	0	0
Nose polypi	1	0.7	0	0
Other symptoms	3	2.2	1	1.8
No nasal or eye symptoms	73	52.5		

¹ The numbers shown for 55 persons who could graduate their nasal and eye symptoms.

toms. The symptoms were graded as light in 17 % and heavy in 14 %.

Skin test

Nineteen persons (14 %) had a positive skin test ($\geq 1+$) to one or more of the standard allergen extracts. The allergen that elicited most positive reactions was *D. pteronyssinus* (5 %).

One or more of the three storage mite extracts gave a positive skin test in 11 (8 %) of the participants when used in strength 1,000 NE/ml, but 18 (19 %) when used in strength 10,000 NE/ml. There was no difference in frequency of positive reactions when comparing the three individual storage mite species. The frequencies were (strength 10,000 NE/ml): *A. siro* 14 (15 %), *L. destructor* 5 (5 %) and *T. putrescentiae* 14 (15 %). A positive skin test to one or more of the standard allergen extracts was related to positive skin test to one or more of the storage mite extracts (Table 3). There was no relation between reactions to storage mites and *D. pteronyssinus*. Of those with a positive prick test to storage mites (strength

Table 3
Relationship between the results of skin tests to the standard allergen extracts and skin test to the storage mites

Extract strength: 1,000 NE/ml	Positive skin test to one or more standard allergens		
		+	-
Positive skin test to one or more storage mites	+	7	4
	-	12	116
		19	120
			139

McNemar's test (with Yates' correction): $\chi^2 = 3.06$, $0.05 < P < 0.10$

Extract strength: 10,000 NE/ml	Positive skin test to one or more standard allergens		
		+	-
Positive skin test to one or more storage mites	+	8	10
	-	4	72
		12	82
			94

McNemar's test (with Yates' correction): $\chi^2 = 1.78$, $P: \text{N.S.}$

10,000 NE/ml) 33 % (6/18) reacted positively to *D. pteronyssinus*.

Other tests

Only three participants had a positive RAST (class 2 or more) to one or more of the storage mite species. One person had positive RAST to all four species, one person to three species and one person to one species. No persons had a positive RAST (class 2 or more) to wheat. Among workers with a positive prick test to one or more storage mites (10,000 NE/ml) the frequency of a positive RAST to storage mites was 17 % (3/18).

Total IgE was elevated (> 122 U/ml) in 10 % of the participants. Elevated total IgE was related to a positive skin test to one or more of the storage mite species.

By spirometry 13 (9 %) had airway obstruction (abnormally low FEV₁ and FEV₁/VC). Two of these 13 persons improved significantly

in FEV₁ after inhalation of salbutamol (27 % and 19 % improvement).

The group with airway obstruction was older (Mann-Witney U test: *P* = 0.0002) and the length of employment tended (*P* = 0.053) to be longer than that of the group without spirometric signs of airway obstruction.

Six participants had work-related respiratory symptoms and a positive skin prick test (≥ 3+) to one or more storage mite species (10,000 NE/ml). This gives a frequency of 6/94 = 6.4 % (1.5 %–11.3 %) of respiratory storage mite allergy. Three of these six participants were RAST-positive to storage mites.

Another nine workers had a reaction to storage mite extracts of 3+ or more but no respiratory symptoms. This gives a frequency of sensitization to storage mites of 15/94 = 15.9 %.

Among workers with work-related respiratory symptoms, the frequency of storage mite allergy was 13.9 % (6/43), with 95 % confidence level 11.0 %–16.8 %.

Table 4
Result of history, prick test, RAST, total-IgE and spirometry among 11 grain elevator workers with manifest or suspected respiratory allergy

Person No.	History of resp. allergy		Prick test ¹							RAST					Total-IgE elevated ³	Airway obstruction
	Work related	Not work related	Standard panel	Storage mites						A	L	T	G	W ²		
				1,000 NE/ml			10,000 NE/ml									
				A	L	T	A	L	T							
Group 1																
1	pos.		0	0	0	0	0	0	0	0	0	0	0	0	+	+
2	pos.		0	0	0	0	0	0	0	0	0	0	0	0	+	0
3	pos.		0	0	0	0	0	0	0	0	0	0	0	0	++	(+)
Group 2																
4		pos.	timothy	0	0	0		-		0	0	0	0	0	+	0
5		pos.	cat	0	0	0		-		0	0	0	0	0	0	(+)
Group 3																
6	pos.		0	0	0	0	3	0	3	0	0	0	0	0	+	0
7	pos.	pos.	<i>D. pter.</i>	0	0	0	3	0	3	2	2	2	2	0	+++	0
8	pos.		0	2	0	2	3	0	2	0	0	0	1	0	++	0
9	pos.		0	4	0	2	5	2	0	3	0	0	0	1	+++	0
10	pos.		0	0	0	0	3	3	3	0	3	2	2	0	0	0
11	pos.		0	0	0	0	0	2	3	0	0	0	0	0	0	0

Group 1: History and total-IgE suggest allergy, but a relevant allergen has not been found.
Group 2: History and prick test are compatible with allergy towards common allergens.
Group 3: History and prick test are compatible with storage mite allergy and in one case (No. 7) allergy to *D. pteronyssinus*.
¹ Positive reactions graded according to the histamine reaction (1).
² A: *A. siro*; L: *L. destructor*; T: *T. putrescentiae*; G: *G. domesticus*; W: Wheat.
³ +: total-IgE > 122 U/ml; ++: total-IgE > 200 U/ml; +++: total-IgE > 300 U/ml.

In Table 4 the results of questionnaire, prick test with standard allergen panel and storage mites extracts, RAST to storage mites, total IgE and spirometry, are indicated for 11 workers with manifest or suspected respiratory allergy to storage mites or other allergens.

Based on an individual estimation of the participant's occupation, a tentative graduation of exposure to grain dust was made. Most of the grain elevator operators (60 %) were considered to have a high exposure level, while that of drivers and craftsmen (22 %) was designated variable. A proportion of grain elevator operators and workers with other functions (18 %) had a low exposure level.

There was no difference in the prevalence of work-related respiratory symptoms, work-related pulmonary symptoms or frequency of positive prick test ($\geq 3+$) to storage mites between the three levels of exposure.

The mite species *A. siro*, *L. destructor* and *T.*

longior were found in 45 (73 %) grain samples (Table 5). In four samples infestation was high, about 30,000 mites per kg grain. In these samples eight different mite species were identified, of which *Tarsonemus* sp. was found in about the same number as *A. siro* and *L. destructor*.

Mites were found in all dust samples (Table 6). *Tarsonemus* sp. occurred almost as frequently as *A. siro* and *L. destructor*.

DISCUSSION

Previous epidemiological studies from USA and Canada have shown that grain handlers have a higher prevalence of acute and chronic respiratory symptoms than comparable workers, who do not handle grain, and that grain dust exposure has an adverse effect on airway function independent of the effect of smoking (3, 5, 16).

Preliminary data from an uncontrolled study among grain handlers in Britain have shown that positive prick tests to storage mite extracts were significantly correlated to work-related respiratory symptoms, and that 62 % of workers with work-related asthma had a positive prick test to more than one storage mite species. Skin test responses to extracts of *D. pteronyssinus* and grain dust did not correlate to work-related respiratory symptoms (4).

A statistical relation between environmental exposure (farmers, grain elevator workers and bakers) to storage mites and positive skin prick test to one or more of the storage mites extracts has been shown among consecutive patients with respiratory allergy (18, 19).

The prevalence of respiratory symptoms in our study was considerably lower than prevalences among North American grain elevator workers. For instance, do Pico et al. (16) found the following frequencies (with our frequencies in parantheses): dyspnea 45 % (15 %), wheezing 65 % (20 %), expectoration 37 % (13 %) and chronic bronchitis 49 % (11 %). Also the frequency of abnormal airway obstruction in our study was lower than in the study of do Pico et al (9 % vs. 16 %). The differences cannot be ascribed to differences in age, length of employment or smoking habits, as these parameters

Table 5

The distribution of mite species among a total of 110,072 mites isolated and identified in 72 samples of grain from four grain store companies. The samples were taken from March to April 1985

	Total numbers (%)	Frequency in samples (%)
<i>A. siro</i>	35	42
<i>L. destructor</i>	25	63
<i>T. longior</i>	3	11

Table 6

The distribution of mite species among a total of 261 mites isolated and identified in 18 samples of dust from transport works, silo ceiling and ventilation systems in four grain store companies. The samples were taken from March to April 1985

	Total numbers (%)	Frequency in samples (%)
<i>A. siro</i>	49	89
<i>L. destructor</i>	31	78
<i>Tarsonemus</i> sp.	7	67
<i>Tyrophagus</i> spp.	4	33
Other ¹	9	50

¹ Includes: *Pyemotes* sp., *Cheyletus eruditus*, *Gohieria fusca*, *Thyreophagus entomophagus*, *Coproglyphus* sp., *Mesostigmata* spp. and *Caloglyphus* sp.

are comparable between the North American studies and our study.

The difference probably reflect differences in interviewing technique and questionnaire. Another important factor could be a higher concentration of airborne dust in North American grain stores compared to Danish companies.

In all allergy diagnosis, the allergen extract is of crucial importance. We found that our commercial extracts of storage mites in strength 1,000 NE/ml were probably too weak for screening in a storage mite exposed population, as only one of three RAST-positive participants were also prick test-positive to storage mite extract in strength 1,000 NE/ml. In contrast, all three were prick test-positive to storage mite extracts in strength 10,000 NE/ml.

Our RAST results showed that compared with the prick test to storage mites, RAST is rather insensitive. This probably reflects that about half of the workers with work-related respiratory symptoms had only rhinitis symptoms.

Faunistic examination of hay and grain (7, 12) have shown that *Tyrophagus* in temperate zones is predominantly represented by *T. longior*. This was confirmed in the present study. Extracts of this species were not commercially available. However the close relationship between this species and *T. putrescentiae*, which was available, could imply common allergenic determinants.

Among farmers in Scotland, storage mites have been established as an important cause of occupational allergy. Cuthbert et al. report a 21% frequency of "barn allergy" (allergic respiratory symptoms with deterioration on exposure to hay dust, and positive prick test to one or more storage mites (8)). The frequency of "barn allergy" even appears to be underestimated as 64% of farmers with allergic symptoms not associated with hay dust were prick test-positive to storage mites.

A recent report from Sweden showed a high prevalence (40.0%) of immediate type hypersensitivity reactions among farmers on the island of Gotland (13). The prevalence of atopic allergy based on positive reactions ($\geq 2+$) to one or more allergens in a standard panel of

allergens (strength 10 HEP) was 15.6%. The calculated prevalence of storage mite allergy based on case history and a positive RAST to at least one of four storage mite species was 6.2%.

We used essentially the same RAST technique with the same mite species, but found a frequency of positive RAST in only about one third (2.2%). The difference might be explained by a lower level of exposure to storage mites in the grain industry, but also the pressure of selection on health in the two occupations could be different. However, the prevalence of positive reactions ($\geq 2+$) to the standard panel of allergens was similar in the two studies (15.6% vs. 12.9%).

We have shown that respiratory allergy to storage mites seems to be of importance in grain handlers. The prevalence was 6.4% but might vary with the diagnostic criteria and be influenced by selection processes in the working force preceding this cross-sectional study. The storage mite allergen appears to be the most important of the allergens tested among grain elevator workers in Denmark. Skin test results of $\geq 3+$ revealed that seven reacted to storage mites only, three to storage mites and other allergens, and three only to other allergens. Other possible allergens (flour, rodent hair or excretes, insects), which were not included in the prick test panel, might also be relevant to this occupation. The same applies to the storage mite *Tarsonemus* sp., which occurred frequently in the dust samples.

ACKNOWLEDGEMENTS

The authors are grateful to Jens Korsgaard, Ph.D. and Thor kil Hallas, M.Sc. who analysed the samples of grain and grain dust for mite content and also revised the manuscript.

This study was supported by the National Association against Tuberculosis and Respiratory Diseases, Engineer Chresten Otto Hansen and wife Gudrun Edele Harriet Hansen's Foundation, Danish Medical Research Council (grant No. 12-5862), the Medical Research Foundation for North Jutland County and Consultant Physician Heinrich Kopp's Foundation. Pharmacia kindly supplied us with allergen extracts and performed the RAST analyses.

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