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MITE ALLERGY AND MITE EXPOSURE IN ICELAND

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Abstract: In this overview of investigations into mite allergy in Iceland and of the current understanding of the sources of exposure, 2 major categories of mite-induced allergies were encountered. The first was house dust mite allergy due to house dust mites from unknown sources, and the second was barn allergy caused by mites connected with the degradation of stored hay. Characteristics of these diseases have been obtained from surveys where skin prick tests were made with commercially available extracts of mites and from zoological investigations where mites had been found in different kinds of dusts relevant for the tested persons. The investigations uncovered a discrepancy between the capital Reykjavik and countryside farms. While the frequencies of sensitization to house dust mites and barn mites are rather similar in the capital area and in the rural area, the exposure to these mites is unexpectedly low in the capital area. Thus, sensitization appears to take place preferably in the rural area.

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INTRODUCTION

Exposure to mites at home or at work is a common cause of allergy and asthma in most Western countries. The frequency of exposure and diseases is similar in countries with comparable geographic and climatic conditions. Iceland, in contrast, presents a special case with its mid-ocean setting combined with a subarctic climate. Two major categories of mite allergies in Iceland have been recognized so far: House-dust mite allergy and Barn allergy.

ALLERGY AND DOMESTIC EXPOSURE TO MITES

In Iceland, 2/3 of the population live in the capital of Reykjavik and its suburbs. The prevalence of IgE-mediated allergy in this area is known from 2 international surveys (A & B).

A. The European Community Respiratory Health Survey in 1990-1993 (ECRHS I). This survey was conducted in almost all European countries using the same methods. It showed that 20.5% of young adult individuals had a positive skin prick test (SPT) to one or more allergens (≥ 3 mm weal reaction) and 23.6% had specific IgE to one or more allergens (timothy grass, cat, mites, birch, *Cladosporium*) [9]. Measured in this way the atopy prevalence was lowest in Iceland compared to other Western nations [2]. Of the Icelanders studied, 6.1% had a positive skin prick test to *D. pteronyssinus* and 9.2% had specific IgE to *D. pteronyssinus* (≥ 0.35 KU/L) [1]. These levels were lower than the average in the other participating countries [3] but similar to the levels found in Sweden and Italy.

Symptoms were compared between those who were house dust mites (HDM) positive and those who were HDM negative but positive to grass allergens. No difference was observed between the groups in terms of history of wheezing, asthma, eczema or other symptoms when exposed to pillows or duvets. This indicates that specific IgE to HDM is not related to any specific symptoms [1].

B. International Study of Asthma and Allergies in Children (ISAAC) in 2000–2001. The ISAAC study measured

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the global prevalence and severity of asthma symptoms in children, based on a cross-sectional questionnaire survey of children. Results showed that 24.3% of 10–11 year old children in Reykjavik and suburbs exhibited positive skin prick tests to one or more allergens, a result similar to the result for Sweden but, in contrast to young adults in the ECRHS I, higher than in the UK and Estonia [4]. In this study, 3.0% of the Icelandic children had specific IgE to *D. pteronyssinus* and 1.4% to *D. farinae*. This prevalence was higher than in Sweden but lower than in the UK. In the ECRHS I, the prevalence of positive SPT to *Lepidoglyphus destructor* in the Reykjavik area was 3.2%, but 6.3% if defined as an SPT reaction of ≥ 1 mm. Using a skin reaction of ≥ 1 mm as a limit, people who fed horses most often had positive prick tests (14.7%) [8] and those who had been exposed at some time to hay dust were significantly more often positive to *L. destructor* than those who had never been exposed (7.8 *vs.* 5.0%).

In 2001–2002, dust samples were collected from beds in c. 200 homes in Reykjavik. We expected to find that Reykjavik inhabitants who showed responses on SPT to house dust mites as well as mites from stored hay (*L. destructor*) should be exposed to these mites to some extent in their homes. Surprisingly, only 2 *D. pteronyssinus* specimens were found in the whole material, and the allergen analysis identified only traces of Der f 1 in 2 samples but no Der p 1 [15, 24]. In conclusion, the sensitization to house dust mites was unlikely to have taken place in the bedrooms of the inhabitants of Reykjavik. Nor were storage mites like *L. destructor* or *A. siro* represented in the dust samples [15]. There are, however, other possible exposures to house dust mites and storage mites in Icelanders. A great majority of the rural population, as well as the majority of the population in the capital and suburbs, may have been exposed to hay dust either occupationally or in connection with horseback riding, a popular sport in this country [8].

Among young people in Reykjavik and suburbs, 70% of the men and 40% of the women had a record of exposure to hay dust during frequent farm vacations (71%), when brought up on a farm (18%), or by feeding horses (11%) [8]. People from the site where the dust samples were collected were closely questioned and it appeared that 66% of those having a specific IgE to *D. pteronyssinus* were men, and 57% had at some time spent their childhood summer vacations on a farm, whereas in the control group of people with grass allergy but no HDM allergy, only 31% were men and 40% recounted rural childhood experiences. We also looked for IgE antibodies to cross-reactive allergens to HDM and found that 55% in the active group and 0% in the control group had one or more such antibodies [1]. The positive cross-reactive antibodies were *L. destructor*, shrimp, cockroach, mosquito, tropomyosin and chironomids, in declining order of frequency. Neither cockroaches nor mosquitoes are part of the Icelandic fauna [1].

We concluded that people in Reykjavik who had specific IgE to *D. pteronyssinus* were more often men who

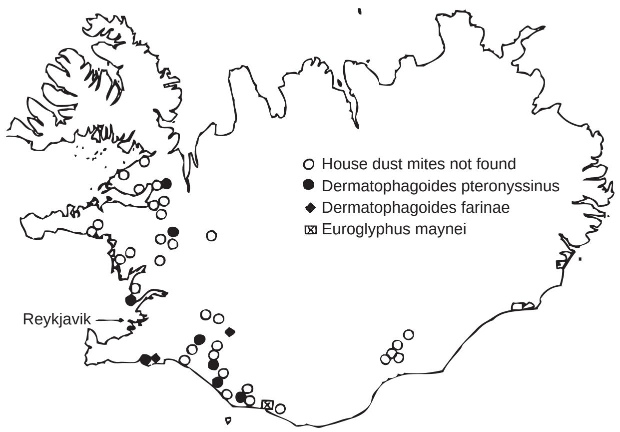

Figure 1. House dust mites found in house dust samples in 42 dwellings on sheep farms in Iceland. *D. pteronyssinus* was encountered on 8 farms, *D. farinae* on 2 and *E. maynei* on one farm [12].

had spent time on farms in their childhood and had a high prevalence of cross-reactive antibodies to *D. pteronyssinus*, which indicates that IgE antibodies to HDM may be an expression of sensitization to other allergens cross-reacting to HDM; this interpretation is supported by the negative findings for cross-reacting allergens in the control group. Another possibility is that exposure to HDM on farms had led to sensitization, as information about HDM in farmhouses was not available at that time [1].

In connection with an occupational health investigation of sheep farmers in S and W Iceland, dust samples were collected from the bedrooms and living rooms in 42 farmhouses [12]. We anticipated seeing no house dust mites, as in the Reykjavik investigation, but that the mites in farmhouses would be represented mainly by storage mites and thus reflect the high concentrations met with in the nearby hay stores. In contrast, what we actually found was that some farmhouses the dust samples harboured significant amounts of house dust mites (Fig. 1).

The mite *Acarus siro* s.l. was the most frequent and appeared in 13 farmhouses. It might be a link to hay exposure in the nearby barns, but the distribution of this species in the material indicates instead a correlation to decreasing distance to the seashore. None of the mites, however, appeared in large numbers or seemed to be part of an indoor fauna [12], and might be a contamination from the open [20].

The relevance of house dust mite allergy in Iceland, however, remains undecided. It is hard to know in an environment rich with storage mites if symptoms are due to *Dermatophagoides* spp., storage mites or cross-reactivity to their allergens. Some Icelandic allergologists do not consider house dust mites a serious challenge to Icelanders but think that they may encounter the disease on travels abroad. Others suggest that at least some allergic rhinitis in Iceland might be caused by exposure to house dust mites. If considered relevant, the avoidance measures proposed to the patient are those known from the recommendations in the literature.

Table 1. Sensitivity (SPT) in Icelanders to selected mites. Results from 3 studies.

Skin Prick Testings (SPT)	Reykjavik	Countryside farms	
Source	[9]	[6]	[12]
Number of persons tested	537	103	42
Year of testing	2000–2001	1982	2005
% of persons positive SPT for…			
Dermatophagoides farinae	n.a.	14	2
D. pteronyssinus	6	10	5
Lepidoglyphus destructor	3	38	12
Acarus siro s.l.	n.a.	14	n.a.
Tyrophagus putrescentiae	n.a.	17	n.a.

OCCUPATIONAL ALLERGY (BARN ALLERGY) IN ICELANDIC FARMLAND

In contrast to house dust mite allergy in Iceland, barn allergy is a well-recognized and elucidated disease in our country. The awareness of hay-caused occupational diseases increased after the middle of the 20th century, as well as knowledge of the mechanism behind these diseases. Jack Pepys wrote about precipitating antibodies in lung diseases among farmers in 1969 [22], and in 1979 Cuthbert *et al.* [5] introduced the term 'barn allergy' due to mites in stored hay on the Orkney Islands, with *Tyrophagus longior* and *Acarus siro* s.l. as the dominant species. During the 1980s, the awareness of health authorities in Iceland was awakened to the health risk of respiratory diseases due to handling of stored hay. This resulted in the formation of a task force working for the Surgeon General of Iceland to study hay-related disease.

In 1983, farmers and their families, 5–50 years of age were studied in 2 areas: in the South, where the annual precipitation was 2,000–4,000 mm and where hay was generally cured by letting it dry in the open air, and in the North where the annual precipitation was 1,000–2,000 mm and hay was almost exclusively cured as silage.

Participants answered questionnaires (n=319) and those with respiratory or skin symptoms (n=103) underwent a prick test. Of these, 55% were positive (weal reaction ≥ 2 mm) to one or more allergens, and 38% were positive to *Lepidoglyphus destructor*, 17% to *Tyrophagus putrescentiae* and 14% to *Acarus siro*, at that time the only available storage mite extracts; meanwhile 14% were positive to *D. farinae* and 10% to *D. pteronyssinus* [6].

Sixty-eight (66% of symptomatic individuals) related their symptoms to work with forage. While no difference between skin test positive and skin test negative individuals was found regarding cough, dyspnoea and fever after exposure to hay dust, those with positive skin tests significantly more often had symptoms in the nose and eyes [13]. No statistical significant difference was found between the 2 areas (North *vs.* South) regarding symptoms or skin test results in this age group.

In the same areas, 451 farmers were tested by precipitin tests for *Saccharopolyspora rectivirgula* (synonym: *Micropolyspora faeni*), *Thermoactinomyces vulgaris* and *Aspergillus fumigatus* antibodies. They also underwent spirometry and answered a questionnaire. In the southern area, 73% had a positive precipitin test, 19% had anamnesis of fever after work in hay dust, and 25% had abnormal spirometry. In the northern area, the respective figures were 23%, 8% and 10% ($p<0.001$, $p<0.01$, $p<0.001$, respectively) [21]. Thus, there seemed to be a link between morbidity among farmers and the mode of haymaking and storage.

In an occupational health investigation of 2005 sheep farmers in S. and W. Iceland, 42 of them were tested by SPT (Tab. 1). One was positive for Der f 1, 2 for Der p 1 and 5 for Lep d 1 [12]. These figures are consistent with results in the former investigation, where only those with skin or respiratory problems were tested (Tab. 2).

Table 2. Possible exposure of Icelanders to the mite species used in the SPT test panel in Table 1.

Mites identified in the environment	Reykjavik	Countryside farms		
Sites	bedrooms	bedrooms	sitting rooms	barns
Source	[15]	[12]	[12]	[13]
Year of collection	2000–2001	2005	2005	1981
Number of samples	194	39	41	36
Nature of samples	dust	dust	dust	mites
Collection method	vacuuming	vacuuming	vacuuming	heat extraction
Origin	mattresses	mattresses	floorings	stored hay
% samples positive for the mites				
Dermatophagoides farinae	0	3	2	0
D. pteronyssinus	1	18	12	0
Lepidoglyphus destructor	0	3	5	83
Acarus siro s.l.	0	21	22	81
Tyrophagus putrescentiae	0	0	0	0

HAY MITES – THE CAUSE OF BARN ALLERGY

The major farm crop in Iceland is hay, a substrate inhabited by mites. Exposure was studied from 1981 hay collections, where the mites in stored hay were identified, and it appeared that the amount of mites was impressive, up to 1 million per kg hay with an average of 50,000 [13].

The mites seemed to be the consequence of fungal growth associated with the decay of the stored hay. It is a natural process in the open, but when hay is to be stored as feed for livestock the process may reduce the nutritional value of the feed and, as we learned, expose the farmers to dust from mites. In Icelandic fields the grass is infested by 3 dominant mites: *Penthaleus major* [16], *Bryobia cristata* [17] and *Tyrophagus similis* [18], but they die out when the grass is cut although their residues remain in the hay when it is stored. Apparently the process of harvesting and initiation of storage constitutes no particular challenge to a mite-sensitized person. Later, however, the handling of stored hay to feed the livestock may expose the farmer to massive amounts of airborne dust containing storage mites and their residues. The problem begins a few months after the hay has been laid in, and gradually worsens during the storage period because the number of mites increases and their residues accumulate. In many countries this is a phenomenon of short duration, but in Iceland the livestock must be fed in the barns for about 6–8 months of the year, thus ensuring a long period of occupational exposure. Further, the need to have a sufficient supply of hay forces the farmers to have a reserve stock, which may have been stored for 2 or more years (up to 25–30), becoming a potent source of mite dust when it is eventually used.

The composition of the hay fauna depends on the biological age of the stored hay. Freshly harvested hay is almost void of live storage mites, but as decomposition progresses the carbohydrate content is slowly released as CO_2 and H_2O, the latter creating a water activity high enough to support the growth of a number of microfungi (*Eurotium* spp., *Emericella nidulans*, *Absidia* spp. *Acremonium* spp., *Aspergillus candidus*, *A. niger*, *A. sydowi*, *A. versicolor*, *Cladosporium herbarum*, *Mucor racemosus*, *Penicillium atramentosum*, *P. melanochlorum*, *P. viridicatum*, *Rhizopus nigricans*, *Scopulariopsis brevicaulis*) [10, 14]. The numerically dominant species of mites found are *Lepidoglyphus destructor*, *Acarus siro* s.l., and *Tarsonemus* spp., while mites like *Tyrophagus longior*, *Ctenoglyphus plumiger*, *Cheyletus eruditus* and *Tydeus interruptus* and others are present in the successions, but usually only in moderate concentrations [13]. The first in the succession of mites is *L. destructor*, while *A. siro* s.l. appears later, and in the most deteriorated hay, which is quite slimy, we find the species *Tydeus interruptus*, *Pygmephorus islandicus* and members of the insect group Collembola and a small fungal-eating beetle, *Enicmus minutus* [14].

We may expect that a species appearing first in the succession, like *L. destructor*, whose residue is deposited in the hay dust for the rest of the storage period, will be the primary challenge for the farmers handling the hay, while exposure to the later appearing species like *A. siro* might be quantitatively less; so far, the few results from SPT of exposed farmers do not contradict this conclusion.

The mite *T. putrescentiae* has not yet been recorded in Iceland. Therefore, the positive SPT results for *T. putrescentiae* (Tab. 1) may be due to cross-reactivity between this species and *T. longior* or *T. similis*, the latter being frequent in the grasslands [18]. In much warmer climates, in contrast, such as in Spain and France, the *Tyrophagus* niche in stored hay may be occupied by *T. putrescentiae* [19].

The prohibition of fungal growth may be carried out by keeping the hay dry enough to delay its decay by microorganisms until the time when the hay is used. Gudmundsson and Hallas [11] found only a few mites when the initial water activity of the hay was below 0.73, corresponding to a moisture content of 11%. Ideally, one might avoid both fungi and mites by keeping the water content of the stored hay well below 10%, but it is an impractical and expensive way to control mites. Most stored hay is compacted by its own weight and may develop heat and excess humidity which can be removed by cooling and ventilation, either forced or natural. After a year, all dry stored hay has become equilibrated to the average annual moisture content of the air in the open, RH 82%, causing a water activity of the hay of 0.82 and 17% moisture content [11].

Some of the problems of exposure to allergenic mites and their remains have been solved by technological means. Ensilage with derivates of propionic acid for hay conservation blocks microbial growth. Icelandic farmers reported that with this treatment there was no longer a problem with hay dust. Another method, plastic wrapping, is now widely used in Iceland. Hay is fresh cut and stored airtight in the fields or in barns. The low concentration of oxygen preserves the hay so that fungi do not grow and, in principle, decay is halted and the airtight sealing is not broken until the bale is opened for use as feed. It is claimed that hay stored in this way does not harbour mites, but no one seems to have undertaken research to check whether this is so.

DIFFERENCES BETWEEN CAPITAL AND FARMLAND EXPOSURES

It appears that the main exposure in Iceland to mites and their allergens takes place in the countryside, while the citizens of the capital, Reykjavik, are almost unexposed. Thus, we might expect that the prevalence of atopic lung diseases should be greater in the rural population because of their obvious exposure to mites. But this is not the case, as the latest survey shows no statistically significant difference in this respect between the capital and rural populations [23]. However, a few complaints due to dust from stored hay still persist in the farming population, though the number seems to be declining due to the new technologies that minimize dust production and therefore the farmer's exposure.

That bedrooms in the capital of Iceland – in contrast to those in the rural areas – were almost devoid of house dust mites and their allergens was surprising. Pinpointing and understanding the causes for this difference may lead to answering the question of whether a similar freedom from mites can be achieved elsewhere, for example, in the homes of allergic persons, hospitals and elsewhere where a mite-free indoor environment would be desirable.

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