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Hay diseases in Iceland

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ABSTRACT

Diseases due to work in hay dust have long been known in Iceland and the first written records of them appear in the beginning of the 17th century. At the end of the 18th century, a district doctor alleges that they cause many deaths in the country. In the latter part of the 20th century, research was started to investigate the causes and nature of hay diseases in Iceland. Studies of allergens showed high levels of storage mites in hay. Highest levels were of *Tarsonemus* sp., *Acarus farris* and *Lepidoglyphus destructor*. A several micro-fungi were also found, most commonly *Rhizopus* sp., *Penicillium* sp. and *Aspergillus* sp. *Micropolyspora faeni* was also found in all hay samples.

A study was done on people aged 6-50 years in two districts in Iceland. In one district farmers used almost exclusively dry hay and in the other they used 80-90% silage. There was no difference in IgE-mediated allergy between the provinces, but most had positive skin tests for *L. destructor* and cattle. Those with symptoms connected with hay dust most often reported nasal symptoms (79%), eye symptoms (63%), cough (41%), dyspnea (32%) and fever (21%). Those who had positive skin reaction complained most often of nose and eye symptoms.

A study was also conducted on subjects aged 16-87 years from the same regions investigating precipitin tests for *M. faeni*, *Thermoactinomyces vulgaris* and *Aspergillus fumigatus*. Pulmonary symptoms and lung function were also investigated. Precipitin tests were almost exclusively positive for *M. faeni*, and 5 individuals were positive for *A. fumigatus* and none for *T. vulgaris*. The precipitin tests were significantly more often positive in those working almost exclusively with dry hay (72.9% vs. 23.9%). They had also more commonly obstructive pulmonary disease (FEV1/FVC%<70: 24.8% vs. 9.5%) as well as dyspnea when walking on level ground. There was a positive correlation between positive precipitin tests for *M. faeni* and dyspnea walking on level ground.

The sensitivity and specificity of positive precipitin tests for *M. faeni* were investigated to detect farmer's lung. The sensitivity was 82% and specificity was only 49%. A survey of emphysema in patients in the only Pulmonary Clinic in the country showed that farmers had more often emphysema than the rest of the country population, and 58% of farmers with emphysema had smoked compared to 94% of other emphysema patients.

Keywords: Hay diseases, Iceland, IgE sensitization, farmer's lung, storage mites, emphysema.

INTRODUCTION

Historical overview: Iceland is an island in the North Atlantic, located in latitude 66.3–63.2. According to the Book of Settlements (Landnáma book) the country was settled between the years 870-930 A.D., mainly by free Norwegians, who brought with them many slaves of Celtic origin. Genetic studies indicate that about 75-80% of the men in the settlement were of Nordic origin, while more than 50% of women were Celtic.¹

The nation's main occupation was farming, and the stock consisted primarily of sheep, cattle, and horses. It was first in the latter half of the 19th century that fishing became very important, and in the 20th century it was the main source of national income. The population of the island was 50-70.000 from the end of settlement until the late 19th century but has since increased considerably and is now around 380.000, of whom 20% are immigrants. Three times the population decreased to about 40.000. This was due to Black Death in 1402-1404, due to smallpox in 1707-1708, and due to famine after the volcanic eruption at Laki in 1783.²

Hay collection has been similar from settlement until the 20th century. The hay was obtained from farmland and, to a lesser extent, from uncultivated land, especially bogs that dried up in midsummer. The grass was spread on dry ground and rotated every day until it was dry. Then it was gathered into hayricks or barns. The hayrick had laden walls and turf was laid on top of the hay.³ By the 20th century, all hay was collected in barns for use during winter.

In the first half of the 20th century, farmers started trying other methods of haymaking, and in a

small area in the north, hay was processed almost exclusively in silage.

Since the time of settlement, the weather is believed to have warmed during the next few centuries, but cooled again in the 13th century, and the cold was at its peak in the 17th century. In the 20th century climate has warmed, and it is now warmer than it has ever been since settlement.⁴

With the worsening climate, difficulties in obtaining hay for the livestock increased, causing occasional famine. Summers in Iceland are short and hay collection mainly takes place in July and August. Cattle is kept in house for eight to nine months, while sheep and horses are kept in for about six months a year. That's the time people had to work in hay dust.

Diseases related to hay dust have been known in Iceland for a long time, almost certainly since the settlement. In the Icelandic sagas (sagas of Icelanders from settlement until the 12th century) there are little accounts of hay-gathering, but there are stories of battles and homicide in hayfields.^{5,6}

The earliest record we have found referring to hay diseases is in an unprinted medical dictionary written in the early 17th century by the Reverend Oddur Oddson.⁷ He wrote the word "heysótt", which now means farmer's lung. The word "heysótt" also appears in a medical book written in 1770.⁸ In a poem from the early 18th century says: "mæddur af heysóttinni." (with shortness of breath from the hay sickness). In 1730-40 a dictionary was published in Copenhagen with the following text in Latin: "Heysótt is also called a bad anorexia which they sometimes get, which in winter dissolve compacted hay in a haybarn with a hayneedle or hayhook."¹⁰ The physician

Sveinn Pálsson writes in 1790: "Heysótt is called an illness that people get who give poorly processed hay in the winter, and it is generally known in Iceland and causes cold, hoarseness and cough."¹¹

Another physician, Jón Pétursson, wrote an article on "heysótt" in 1794 in which he describes the symptoms: "The tightness of the chest of which many people complain in this country, I call heysótt, here to distinguish it from other chest diseases. This weakness is nothing more than what doctors call asthma convulsivum. This disease is included in chronic inertia, when the sick person breathes; Sometimes this ailment is truly relieved but comes back again and again with fits; It is then as if the chest is crushed together, with great turmoil, constriction, and wheezing in the chest, so that the sick may sit upright in bed. Cough is always associated with this disorder often followed by watery foam or slightly blood stained."¹²

In a doctoral dissertation in 1874 physician Jon Finsen wrote on hay disease.¹³ In a brief translation, he says that in Iceland lung disease occurs quite often only to those who feed hay to animals in the winter when they release the hay from a haystack and shake out the dust before donation. When breathing in the dust, especially when the hay is poor and moldy, the worker gets a cough, a slight phlegm and tightness of breath, which is often very intense, especially in the evening after work. The symptoms persist while the hay is fed in winter but disappear in the summertime. Finsen says there is no doubt that this is a disease other than hay fever, which is only in the summer and gives symptoms from the nose and eyes, but this disease gives symptoms from the lungs.

In 1932, Campell gives a more complete description of disease after work in extremely

moldy hay. "*After intensive exposure to the dust, within 36 hours extreme dyspnea developed, with cyanosis, so that the sufferer appeared almost in extremis. Three weeks later dyspnea was still severe, and some cyanosis persisted. Cough was never troublesome, nor was sputum copious. X-ray showed generalized fine stippling, finer than silicosis; later the stippling faded, but an increased tendency to fibrosis appeared*".¹⁴ Campell described an allergic pneumonia of hay dust called *extrinsic allergic alveolitis* in England and *hypersensitivity pneumonitis* in the United States, which is known in Iceland as *farmer's lung*, and he believed that mold in the hay was likely to be the cause of this disease. Twenty-one years later, Fuller described three stages of farmer's lung.¹⁵

In the 1960s, Pepys wrote articles about positive precipitin tests in farmers with farmer's lung. The tests were found to be mainly positive for *Thermoactinomyces* sp., but to a lesser extent to micro-fungi.¹⁶ Knowledge of IgE-mediated allergy for hay dust gained momentum with research by Cuthbert in Orkney, which showed that storage mites in hay were the main cause of this type of allergy.¹⁷

Reports by district doctors to the Medical Director of Health in the first half of the 20th century indicated that hay diseases were common in some medical districts of Iceland. It was also obvious to doctors dealing with allergies and lung diseases after the middle of last century that diseases related to work in hay dust were very common. Their symptoms could often be compatible with IgE-mediated allergy, and sometimes delayed allergic reactions or symptoms due to the irritant effects of the hay dust. Doctors brought this to the attention

of the Farmer's association and at their request, the Medical Director of Health appointed a working group the year 1980 to conduct research into the causes and symptoms of these diseases.

The working group approached Thorkil Hallas, Danish Pest Infestation Laboratory Lyngby and Susanne Gravesen Allergy Laboratory (ALK) Copenhagen for expertise and research of antigens in the hay.

MATERIALS and RESEARCH RESULTS

Research on stored hay.

The first phase of the study was to investigate possible allergens and other antigens in hay. Thirty-six samples of stored hay were collected from 12 farms scattered across the country and they were placed in Berlese funnels. The mites, driven out by this process, were cleared and

colored in lactic acid with Lignin pink and subsequently counted. Identification took place at x 100 or more by means of a phase contrast microscope.¹⁸ Storage mites were found in all the samples, ranging from 64 to 1.2 million in one kilogram of hay. There were different amounts of mites depending on where in the barn the samples were taken, and more mites were found close to the walls than in the middle of the barn. In moisture-damaged hay there was manyfold the number of mites compared to what was found in dry hay. Nineteen species of mites were identified, but 5 species were by far the most common (Table I). They were found in all hay samples, and they accounted for 96.7% of all mites found. *Tarsonemus* sp. was found most often, but this species has not been described before in stored hay.¹⁸ It is not known whether *Tarsonemus* sp. causes IgE-mediated allergy.

Table I. Most common species of storage mites in 36 hay samples.

The five most common species of storage mites	Proportion (%) of total storage mites	Proportion (%) of positive samples
1. <i>Tarsonemus</i> sp.	33.5	97
2. <i>Acarus farris</i>	30.4	81
3. <i>Lepidoglyphus destructor</i>	25.7	83
4. <i>Tydeus interruptus</i>	6.3	78
5. <i>Cheyletus eruditus</i>	0.8	50
Samples 1-5	96.7	100

When the number of mites were compared to the age of the hay, most of *L. destructor* and *A. farris* were found in new or year-old hay, but other species of mites were more common in two-year-old hay. Older traces of hay contained few mites, and if the relative

humidity in hay was below 73%, very few mites were found.¹⁸

To investigate other allergy factors, hay samples from southern Iceland and silage from northern Iceland were collected. The samples were

tested for mold, thermophilic actinomycetes, pollen and mouse allergens.¹⁹ The samples were examined at the microbiological laboratory at ALK in Copenhagen. Culture of micro-fungi was performed on V-8 agar with the addition of Penicillium and Streptomycin to prevent growth by bacteria. Hay dust was taken from 35 samples of hay from southern Iceland. There were 15 species of micro-fungi cultivated. The most common were Rhizopus sp. in 83 %

of samples, Penicillium sp. in 29 %, Aspergillus sp. in 23% and Scopulariopsis sp. in 17% of the samples. In 10 hay samples from the same area, 30 grams were chopped and cultured (Table II).¹⁹ Most of Rhizopus and Aspergillus were grown there, and Micropolyspora faeni was grown in all the samples, but none of Thermoactinomyces vulgaris. Five samples of silage were also taken and treated in the same way, but very little was grown.

Table II. Microorganisms recorded from cultivation of 10 samples of stored hay.

Fungi	Good hay	Good hay	Mouldy hay	Very bad hay	3 years old hay	3 years old hay	One year old hay	One year old hay	One year old hay	One year old hay
Absidia sp.		x		x		x			x	
Aspergillus fumigatus	x	x		x	x	x				
Aspergillus niger			x	x						
Aspergillus sp.					x			x	x	
Chaetomium sp.	x				x					
Chrysosporium sp.					x		x			
Mucor sp.			x					x		
Rhizopus sp.	x	x	x	x	x	x	x	x		x
Scopulariopsis sp.			x							
Trichoderma sp.									x	
Micropolyspora faeni	x	x	x	x	x	x	x	x	x	x

Mice came to Iceland with people and are often found in barns. For immunochemical determination of allergens from grass pollen and from mice, an aqueous extract of 10 hay samples mentioned above was prepared according to Schwartz (1978) and stored at -

20° until used. Using Counter Current Immunoelectrophoresis on dust from these 10 hay samples from the southern part of the country, antigens from mouse hair and dandruff were found in three samples and from mouse urine in all samples. Using the same

method, grass pollen antigens were found in 7 samples.¹⁹

Research on diseases related to work in stored hay:

Studies on IgE-mediated allergy in farming families in Iceland: Research was carried out in areas in the South, where hay was dried and stored in a barn, and in areas in the Northwest, where 80-90% of the hay was processed in silage. In the southern zone the precipitation was 2000-4000 mm. per year and in the northern area around 2000 mm. per year. Thus, there was a great difference in climate and methods of haymaking between those areas.

IgE-mediated allergy studies selected farming families aged 6-50 years, 152 individuals in the southern zone and 167 in the northern zone. All participants completed a questionnaire based on a 1966 British Medical Council questionnaire on pulmonary symptoms to which questions about symptoms in hay dust work were added. If participants had respiratory,

ocular and signs of atopic dermatitis, they were prick tested with 24 allergic solutions from ALK. A reaction of ≥ 2 mm was regarded positive.²⁰

Altogether 103 (32.2%) were subjected to skin tests, thereof 68 who complained from hay dust.²¹ Positive skin tests were 55% with no difference between southern and northern regions (Table III).²⁰ Storage mites and cattle gave most commonly positive reaction, but dogs and cats were of little importance. The symptoms of those who underwent skin tests were examined (Table IV). In the southern zone they were 27.6% and in the northern zone 36.5%. It should be kept in mind, that these were all family members and not only those working in hay. Those with symptoms from hay dust mentioned nasal symptoms in 79%, eye symptoms 63%, cough 41%, shortness of breath 32% and fever 21%. Those who had positive skin tests had significantly more frequent nose and eye symptoms, compared with those who had negative skin tests.²⁰

Table III. Prick test results. Positive response rate in farming peoples with symptoms from respiratory tract, eyes and skin (n=103, at age 6-50).

Allergens	Prick test reaction ≥ 2 mm. Proportion (%) of positive responses
Lepidoglyphus destructor	38
Cows	21
Tyrophagus putrescentiae	17
Acarus siro	14
Dermatophagoides farinae	14
Grass pollen	11
Birch pollen	10
Dermatophagoides pteronyssinus	10
Dogs	7

Cats	6
Aureobasidium pullulans	6
Wool	5

Table IV. Symptoms of hay dust in those who were negative (n=46) and positive (n=57) on prick tests.

Symptoms	Proportion (%) negative tests	Proportion (%) Positive tests	Significance
Cough	24	30	N.S
Breathlessness	22	21	N.S.
Fever	13	14	N.S.
Nasal symptoms	28	72	p<0.001
Eye	17	61	p<0.001

A relationship between hay quality and characteristics was investigated (Table V).²¹ The symptoms were almost entirely related to

work with dry hay and moldy dry hay but work with silage yielded little symptoms.

Table V. Symptoms according to types of forage in 319 individuals in South and North areas

Symptom	Silage	Moldy silage	Hey	Moldy hay	Other types*
Cough	2	1	12	25	5
Dyspnea	1	2	11	17	4
Fever	-	-	5	11	3
Nasal	1	2	26	39	9
Eye	2	1	21	29	6
Total	6	6	75	121	26

*Hay from pasture, moldy hay from pasture, hay which has formed heat, hay containing road dust.

Study of precipitin tests, lung symptoms, lung function: This study was conducted in the same areas. The age range was 16-87 years and the mean age was 50.7 years.²² The southern zone had 325 participants and the northern zone 126. All participants completed the same

questionnaire as in the IgE-mediated allergy study. All participants were then allowed to perform a spirometry test using *Vitalograph* and blood was drawn for precipitin test, which was carried out in the University of Iceland Laboratory at Keldur. Precipitin tests were measured for

Micropolyspora faeni, Thermoactinomyces vulgaris and Aspergillus fumigatus. Antigens came from Greer Laboratories Lenoir North Carolina.

Cough, sputum and wheezing were not significantly different from region to region, but significantly more people experienced dyspnea when walking on level ground in the southern zone (13.6% vs 5.6%). Precipitin tests were almost only positive for M. faeni, while 5 were positive for A. fumigatus, while none were

positive for T. vulgaris. The precipitin tests were significantly more often positive in the southern region (72.9% vs 23.9%). There was a positive correlation between dyspnea at ground level and positive precipitin tests for M. faeni ($p < 0.05$). Smokers had less positive precipitin tests ($p < 0.001$). In the southern region, significantly more people had fever after work in hay, and they had significantly more common positive precipitin tests and obstruction on spirometry ($FEV1/FVC\% < 70\%$, 24.8% vs. 9.5%). (Table. VI).²²

Table VI. Symptoms after hay dust exposure, precipitin tests (M. faeni) and spirometry values (Age 16-87 years).

	Area South N = 325 %		Area North N = 126 %		Significance
Cough	40	12.3	18	14.3	N.S.
Shortness of breath	46	14.2	17	14.5	N.S.
Fever	60	18.5	10	7.9	$p < 0.01$
Positive precipitins	237	72.9	29	23.0	$p < 0.001$
FEV1/FVC % < 70%	80	24.8	12	9.5	$p < 0.001$

In the southern region, 12.3% had cough and 11.4% had a phlegm for three months a year, while 14.3% had cough and phlegm in the northern region. These individuals have the diagnosis of chronic bronchitis. In the southern region, 27.7% were smokers and 17.8% were former smokers. In the northern region 26.2% were smokers and 19.8% were former smokers. There was no correlation between cough or phlegm and the results of the precipitin tests.²²

We investigated how sensitive and specific precipitin test for M. faeni would be for diagnosing farmer's lung. The definition for the study was that the patient had worked in hay dust, that he had undergone a precipitin

test for M. faeni, and that lung symptoms were present. Farmer's lung was defined as follows: Repeated attacks of cough and shortness of breath 8-24 hours after work in hay dust. Repeated attacks of shortness of breath with high fever after work in hay dust. High temperature and changes on chest x-ray consistent with farmer's lung after hay dust work.²³ A total of 136 participated in the study, while 51 met the criteria for farmer's lung diagnosis. The sensitivity of the test for M. faeni was 82% and specificity was 49%. Those who had a positive precipitin test had worked longer in hay dust than those who had negative precipitin tests.

Study of emphysema in farmers: Doctors at the pulmonary division of Landspítali University Hospital had noted that farmers with high grade emphysema were admitted there without having smoked. This was the only pulmonary division in Iceland and was attended by patients from all over the country. Altogether 852 hospital patients were examined. They had been admitted the years 1975-84 and had received any of the following diagnoses: Emphysema, chronic bronchitis, asthma, farmer's lung, and/or pulmonary fibrosis. Anamnesis was taken, smoking history and spirometry by Vitalograph. To qualify as a farmer, ten years of farming or work in a hay barn was required. Two experienced chest consultants evaluated the X-rays for the diagnosis of emphysema using the method of Sutinen et al.²⁴ To diagnose emphysema according to Sutinen two of following items were required: 1) Low and flat diaphragm position in x-ray taken from behind. 2) Bullae or reduced vascularity in x-ray taken from behind. 3) Increased space behind the sternum (>2,5 cm). 4) Low and flat diaphragm position on side image. The doctors agreed on results in 841 cases, but in 11 cases they came to conclusion after a discussion. 228 patients had X-rays consistent with emphysema, of whom 30.3% were farmers or former farmers, far higher value than the number of farmers in the population. Among farmers with emphysema, 58% had smoked compared to 94% of non-farmers who had emphysema. Farmers therefore had emphysema, without having smoked, more often than the rest of the group.²⁵

DISCUSSION

It appears that hay diseases have been well known in Iceland from the early 17th century,

as Reverend Oddur Oddsson did not explain the meaning of the word "heysótt" ("hay sickness") like most other words that appeared in his dictionary. People may have long before been familiar with the relationship between hay work and disease, but the first symptoms of "heysótt" are mentioned in the aforementioned poem from the early 17th century which states "sick of heysótt." At the end of the 17th century, it is described that heysótt is well known and causes many deaths.

Studies of hay samples revealed allergens from storage mites, micro-fungi, grass pollen and mice allergens, but these allergens can cause IgE-mediated allergy, and they found that storage mites are by far the most important. *M. faeni* was also found in all hay samples examined with this antigen in mind, while *M. faeni* and micro-fungi can cause late IgG-mediated allergy. The skin tests did not obtain allergens for storage mites except for three species; *L. destructor*, *T. putrescentiae* and *A. siro*. Thus, it is not known if other species of storage mites cause allergies.

Surveys showed that symptoms were almost exclusively confined to work in dry hay, while symptoms caused by silage were negligible. Symptoms associated with IgE-mediated allergy were most pronounced from the eyes and nose, but when comparing the two age groups, there are proportionally more people who complain of shortness of breath and cough in the younger age group. The older age group had stayed longer in hay, and there was a marked difference depending on whether working with dry hay or silage. Significantly more people in the southern region had experienced fever after hay work, they had significantly more positive precipitin tests and

more obstructive ventilatory defect. They also experienced shortness of breath more often when walking on level ground. Dry hay therefore caused more health symptoms than silage.

As noted, 12.3% had cough and 11.4% mucus sputum three months a year in the southern region, while the corresponding figures were 14.3% for both cough and sputum in the northern region. In the southern region 45,5% smoked or had smoked, while the corresponding figure for the northern region was 46%. In Reykjavík urban areas the prevalence of COPD was investigated in the 1990s among those 40 years of age and older. There, 4% of participants had chronic cough and phlegm.²⁶ In that study 61% of both men and women had smoked. For those farmers who got the diagnosis of emphysema, the type of haymaking method they had used was not investigated, but a large majority of farmers in Iceland used only hay.

In a study of a randomized population of individuals aged 20-44 years in the capital Reykjavik and its surroundings, the weight of allergens was quite different from those on farms. Grass pollen, cats, dogs and dust mites were the most important, with *L. destructor* in fifth place.²⁷ Of this population 54.8% had a history of work in hay dust at any time and of those, 7.8% tested positive for *L. destructor* compared with 5% of those who had no association with hay dust ($p < 0.02$).²⁸

We do not have information on keeping pets on the farms that participated in the studies, but it is common practice in Iceland for farmers to have both a cat and a dog in their home. The question is therefore whether it is abnormal for allergies to cats and dogs and grass pollen to be higher in urban areas, but it must be

assumed that pollen levels are much higher in the countryside than in cities. We have no explanation for this difference between rural and urban areas, but some studies suggest that pets in households during childhood, especially dogs, can reduce allergies in adulthood.^{29,30} However, we do not have the possibility to estimate the prevalence of IgE-mediated allergy in the countryside from our studies, although studies from across Europe have shown that growing up on farms reduces the risk of atopic sensitization compared to growing up in towns or cities.³¹

In the last decades of the 20th century, hay production in Iceland underwent drastic changes and almost all hay is now stored in plastic rolls. No studies have been done on the effects of these changes on farmers and those who keep horses for entertainment, but it is the feeling of doctors dealing with allergies and lung diseases that hay diseases have almost disappeared because of this change.

CONCLUSION

Diseases related to work in hay dust have been known in Iceland for at least four centuries. Our surveys have shown that storage mites are a primary cause of IgE-mediated allergy for hay. *M. faeni* is the main cause of positive precipitin tests and farmer's lung. Working with hay is likely to cause IgE-mediated allergies to storage mites. Prolonged work with dry hay can cause decreased walking ability with obstructive pulmonary disease due to chronic bronchitis and emphysema and farmer's lung.

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