with preparations of salivary ducts. Nevertheless, we were unable to find any correlation between the presence of mitochondrial antibodies in the serum and renal or salivary gland involvement. The finding that abnormal responses to kidney and salivary gland antigens were almost confined to patients with clinical involvement of these organs could indicate that cell-mediated mechanisms are more important in their pathogenesis. Furthermore, in certain cases in which biopsy material was available lymphocytic infiltration in the parotid glands and in the kidney was found, similar to that present in the liver.

The presence of cross-reacting antigens in the various tissues could also explain the development of multisystem disease. An initial alteration or release of antigens from the liver after viral or other damage could lead, if the central immune system of that individual is abnormal, to a cell-mediated response involving, in addition to the liver, other organs containing antigens of similar structure. This is supported by recent work of Farrow *et al.* (1971) showing receptors on the chick embryo liver cell which react with an antibody to smooth muscle. However, a few of our patients reacted abnormally only to antigens from salivary gland or kidney, suggesting an organ-specific response, though in almost all of these the test showed stimulation of migration, indicating that the sensitization was slight. To study this problem further it will be necessary to solve the difficult technical problems involved in the isolation and purification of organ-specific antigens.

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References

- Cook, G. C., Mulligan, R., and Sherlock, S. (1971). *Quarterly Journal of Medicine*, **40**, 159.
 Doniach, D. (1970). *Proceedings of the Royal Society of Medicine*, **63**, 527.
 Doniach, D., Roitt, I. M., Walker, J. G., and Sherlock, S. (1966). *Clinical and Experimental Immunology*, **1**, 237.
 Eddleston, A. L. W. F., Smith, M. G. M., Mitchell, C. G., and Williams, R. (1971). *Transplantation*, **12**, 11.
 Farrow, L. J., Holborow, E. J., and Brighton, W. D. (1971). *Gut*, **12**, 494.
 Federlin, K., Maini, R. N., Russell, A. S., and Dumonde, D. C. (1971). *Journal of Clinical Pathology*, **24**, 533.
 Golding, P. L., Bown, R., and Mason, A. M. S. (1970). *British Medical Journal*, **4**, 340.
 Golding, P. L., and Mason, A. M. S. (1971). *Gut*, **12**, 153.
 Hadziyannis, S., Scheuer, P. J., and Feizi, T. (1970). *Journal of Clinical Pathology*, **23**, 95.
 Meyer zum Büschenfelde, K. H., and Kossling, F. K. (1971). In *Immunology of the Liver*, ed. M. Smith and R. Williams, p. 169. London, Heinemann.
 Mookerjee, B., Ackman, C. F. D., and Dossetor, J. G. (1969). *Transplantation*, **8**, 733.
 Nerup, J., Anderson, J., and Bendixen, G. (1970). *Clinical and Experimental Immunology*, **6**, 733.
 Popper, H. (1971). In *Immunology of the Liver*, ed. M. Smith and R. Williams, p. 210. London, Heinemann.
 Rosenberg, S. A., and David, J. R. (1970). *Journal of Immunology*, **105**, 1447.
 Smith, M. G. M., *et al.* (1969). *British Medical Journal*, **4**, 275.
 Sjøborg, M. (1967). *Acta Medica Scandinavica*, **182**, 167.
 Sjøborg, M., and Bendixen, G. (1967). *Acta Medica Scandinavica*, **181**, 247.

Prevalence of Farmer's Lung in Scotland: A Pilot Survey

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Summary

In a survey of the farming population of Orkney, Ayrshire, and East Lothian the prevalence of farmer's lung was estimated at 86 per 1,000 in both Orkney and Ayrshire and 23 per 1,000 in East Lothian. If cases with a negative farmer's lung hay (F.L.H.) precipitin test are excluded these figures are reduced to 43, 36, and nil respectively, but those for Orkney and Ayrshire are still about 20 times higher than any figure previously reported for the prevalence of farmer's lung in Britain.

Regional variations in prevalence are probably related both to climatic conditions and to differences in agricultural methods, the latter often being dictated by economic circumstances. Nevertheless the prevalence of farmer's lung could be reduced considerably by the energetic application of preventive measures, backed by financial incentives. The most important of these are

efficient drying of hay and cereals before storage, more extensive use of silage, better ventilation of farm buildings, and the introduction of mechanical feeding systems. Individual farmworkers could be taught how to recognize the early symptoms of the disease and encouraged to wear respirators when handling mouldy fodder.

Introduction

The disease now called farmer's lung has apparently been known to farmers for over 100 years. Björnsson (1960) mentioned that his grandfather, an Icelandic farmer born in 1855, suffered from it as a young man, and referred to the disease as "heymædi" meaning "hay shortness of breath." It was, however, not recognized as a clinical entity until Campbell (1932) published his original account of "acute symptoms following work with hay" affecting farmworkers in Westmorland. The 1931 hay crop had been harvested under unusually wet conditions, and had become very mouldy during storage. When the last part of the stored crop was being fed to cattle between April and June 1932 several farmworkers developed severe dyspnoea, cyanosis, slight dry cough, and mild pyrexia. They were found to have diffuse dry rales and sibilant rhonchi on auscultation and "fine granular stippling" throughout both lung fields on x-ray examination.

The term "farmer's lung" was first used by Pickles (1944) when he reported a similar case in Yorkshire, but the nature of the disease remained obscure until Pepys *et al.* (1962) found that precipitins against extracts of mouldy hay ("F.L.H. antigens") were present in sera from patients with farmer's lung. Pepys *et al.* (1963) identified *Thermopolyspora polyspora* (now renamed *Micropolyspora faeni*) as the main source of F.L.H. antigen, and Williams (1963) showed that the inhalation of either F.L.H. antigen or an extract of *M. faeni* reproduced the symp-

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toms of farmer's lung and the disturbance of pulmonary function which it caused. These findings, and the characteristic delay of four to six hours between exposure to antigen and the onset of symptoms, suggested that farmer's lung was due to a (type III) diffuse hypersensitivity reaction in the interstitial tissues of the lung to an inhaled antigen derived from the spores of *M. faeni* or some other species of thermophilic actinomycete. It was subsequently discovered that identical diseases were caused by the spores of thermophilic actinomycetes encountered in other occupations, such as the handling of mouldy sugar cane or mushroom compost, and also by other antigens, such as avian protein, porcine pituitary snuff, and the spores of fungi such as *Coniosporium corticale* and *Aspergillus clavatus*.

These diseases are now grouped together under the title of "extrinsic allergic alveolitis," and although this term is unpopular with pathologists, who deny that it correctly describes the histological features of the diseases included in this category, it provides a convenient label for a clearly defined syndrome characterized by the following features: (1) episodes of dyspnoea without wheeze, dry cough, and in some cases fever and malaise, occurring some hours after exposure to the relevant antigen; (2) widespread coarse crepitations on auscultation of the lungs; (3) micronodular pulmonary shadowing on x-ray examination; (4) reduction in forced vital capacity (FVC), carbon monoxide transfer factor (Tco), partial pressure of oxygen in the arterial blood (PaO₂), and pulmonary compliance; and (5) resolution of all these abnormalities on cessation of exposure to antigen, but persistence of the disease in a chronic form if exposure continues.

In Britain farmer's lung is by far the most common form of extrinsic allergic alveolitis, but there is little reliable information on its prevalence. Staines and Forman (1961) recorded figures of 11.5 per 100,000 of the farming population in East Anglia, 73.1 per 100,000 in South-west England, and 193.1 per 100,000 in Wales. This survey consisted of a postal census of cases of farmer's lung which had "occurred" in a series of general practices and chest clinics, and the number of cases in each area was then related to the farming population at risk. Estimates of prevalence made in this way cannot be accurate, because underreporting of cases, as the authors themselves have admitted, is unavoidable. Boyd (1971) recorded a prevalence of 110 per 100,000 of the farming population in the County of Caithness, but this figure was based on the number of patients referred to hospital and must therefore have included only those with more severe forms of the disease.

A diagnosis of farmer's lung is not usually accepted by clinicians unless a typical symptomatic and occupational history is accompanied by characteristic x-ray changes and a positive F.L.H. precipitin test. These criteria may, however, be too restrictive for epidemiological purposes. In some patients with symptoms typical of farmer's lung radiographic opacities either do not develop (Mindell, 1970) or may clear before x-ray examination is carried out, and negative serological findings may be recorded either because the technique is not sufficiently sensitive or because an inappropriate antigen has been used. These possibilities must always be taken into account in the design and interpretation of any inquiry into the prevalence of farmer's lung.

A Working Party appointed by the Scottish Home and Health Department in 1969 to study fungal infection and allergy in agricultural workers decided in 1970 to investigate the prevalence of farmer's lung in Scotland. It would clearly have been impracticable to include the whole of Scotland in the survey, and three areas were therefore selected for a pilot study. On the assumption that the prevalence of farmer's lung would be related both to rainfall and to agricultural methods, these two factors governed the choice of locations. Two counties on the Scottish mainland were chosen, one in the west (Ayrshire) with a high rainfall, and the other in the east (East Lothian) with a low rainfall. Farming practice in both of these counties is fairly

sophisticated, and it was therefore decided that the third area should consist of two Orkney islands (Stronsay and Sanday), where agricultural methods are more traditional, and where rainfall is midway between the Ayrshire and East Lothian figures. The Orkney survey was carried out in July 1970, and the Ayrshire and East Lothian surveys between November 1970 and February 1971.

Method

In Ayrshire and East Lothian all farmworkers, including the farmer, were interviewed on a stratified random sample of farms. The farms were stratified into "small," "medium," and "large," as defined by the Department of Agriculture and Fisheries for Scotland. The number of farms selected in each stratum was chosen to give about equal numbers of subjects in all strata, based on statistics for 1968, which were available at time of planning. The number of persons employed has fallen since then, and more recent statistics led to the revised expected numbers of subjects shown in Table I. The largest changes occurred in East Lothian in the medium and large farms and

TABLE I—Ayrshire and East Lothian—Comparison of Expected and Actual Numbers of Farms and Farmworkers in Sample

County	Size of Farm	No. of Farms in Sample		No. of Farmworkers in Sample	
		Expected	Actual	Expected	Actual
Ayrshire	Small	38	31	57	45
	Medium	31	31	62	59
	Large	19	18	57	44
	All farms	88	80	176	148
East Lothian	Small	51	45	76	67
	Medium	21	16	42	36
	Large	11	11	44	45
	All farms	83	72	162	148

the numbers in these strata were considerably below the original expectations. In Orkney it was decided to interview all farmers and farmworkers on the two selected islands of Stronsay and Sanday.

A questionnaire adapted from the Medical Research Council (1966) *Questionnaire on Respiratory Symptoms* was completed by a trained observer for all farmworkers included in the survey, and a second questionnaire was used to obtain information on agricultural conditions and methods at the farms where they worked. On the basis of the answers to a number of key questions suspected cases of farmer's lung were identified. These patients were then recalled for further investigation by a team of respiratory physicians, who recorded their findings, based on agreed criteria, on a standard form. A full occupational and clinical history was taken, a detailed physical examination was carried out, the forced expiratory volume in one second (FEV₁) and the forced vital capacity (FVC) were measured by Vitalograph, a specimen of sputum, if available, was sent for mycological examination, and a sample of venous blood was taken for serological studies. Each specimen of serum was tested for precipitating antibodies against F.L.H. (*M. faeni*) antigen, obtained from the Public Health Laboratory Service, by a double diffusion plate technique (Ouchterlony, 1958).

A symptomatic diagnosis of farmer's lung was accepted on the following criteria: (1) a history of bouts of dry cough and dyspnoea without wheeze, with or without fever, occurring between November and April; and (2) confirmation by detailed inquiry (a) that the farmworker was exposed to mouldy hay, straw, or grain, (b) that such exposure caused or aggravated the respiratory symptoms, and (c) that the respiratory symptoms developed or became more severe some hours after exposure to the dust hazard.

The differential diagnosis from bronchial asthma presented no problems, because for the purpose of the survey a complaint of wheeze and/or the finding of rhonchi on auscultation automatically excluded a diagnosis of farmer's lung. A few patients who fulfilled the diagnostic criteria also had symptoms consistent with chronic bronchitis, and a diagnosis of farmer's lung was accepted in these cases only if it was confirmed on critical reassessment that they satisfied the criteria laid down in 2 (c) above.

Results

In Orkney all farms were visited on the two selected islands and co-operation was complete. However, a few subjects (12 in Stronsay) were not interviewed because of their temporary absence from the islands for reasons unconnected with the investigation. In Ayrshire co-operation was obtained at 91% of farms, and in East Lothian at 87% of farms. In terms of subjects, 84% of the expected number were interviewed in Ayrshire and 91% in East Lothian. The percentage was lower in Ayrshire because the number of persons per farm in the large farms was smaller than the average figure used in the calculation of the expected number.

The prevalence of symptomatic farmer's lung was 86 per 1,000 in both Orkney and Ayrshire and 23 per 1,000 in East

TABLE II—Prevalence of Farmer's Lung in Orkney, Ayrshire, and East Lothian

	No. of Farmworkers Interviewed	No. of Cases	Crude Prevalence (per 1,000)	Prevalence Corrected for Sampling Method (per 1,000)
Orkney (Stronsay and Sanday)	359	31	86	86*
Ayrshire	148	13	88	86 (S.E. $\pm$ 19)
East Lothian	148	4	27	23 (S.E. $\pm$ 13)

*Standard error not applicable since no sampling was involved.

Lothian (Table II). The standard error of prevalence is a measure of variability due to the sampling method adopted for Ayrshire and East Lothian. With prevalences of the order found, the errors are inevitably large with samples of the size used in this pilot study. Because of these large errors the estimates of the prevalence of farmer's lung in Ayrshire and East Lothian can only be approximate. In East Lothian the overall prevalence could be as low as 5 per 1,000 or as high as 65 per 1,000. In Ayrshire the rate could be as low as 50 per 1,000 or as high as 120 per 1,000. Although there is a slight overlap in these two probable ranges, it can still be said that there is a significant difference, at the 1% level, between the prevalence of farmer's lung in the two counties. Since the figure recorded for Orkney was the same as the Ayrshire figure, it would be reasonable to assume that farmer's lung was significantly more common in both these counties than in East Lothian, though a direct statistical comparison between Orkney and the other two counties could not in fact be made. In the Orkney survey

TABLE III—Prevalence of Farmer's Lung in Orkney Farmworkers

	No. Interviewed			No. of Cases			Prevalence (per 1,000)		
	M.	F.	Total	M.	F.	Total	M.	F.	Total
Stronsay ..	97	38	135	16	1	17	165	26	126
Sanday ..	137	87	224	11	3	14	80	34	63
Total ..	234	125	359	27	4	31	115	32	86

(Table III) there was a higher prevalence in the island of Stronsay (126 per 1,000) than in the island of Sanday (63 per 1,000), and this difference was statistically significant ($P = 0.05$).

An analysis of the sex distribution of the 48 cases in the three areas (Table IV) showed, as would be expected, that males were considerably in the majority. The most striking feature of the age distribution (Table V) was a considerable excess of elderly

TABLE IV—Sex Distribution of Cases

	Male	Female	Total
Orkney	27	4	31
Ayrshire	11	2	13
East Lothian	3	1	4
Total	41	7	48

TABLE V—Age Distribution of Cases

	20—	40—	60—	Total
Orkney	8	12	11	31
Ayrshire	5	7	1	13
East Lothian	2	0	2	4
Total	15	19	14	48

patients with farmer's lung in Orkney, but this may merely reflect the age pattern of the farming population in that area.

The symptoms most frequently recorded were dry cough and exertional dyspnoea, which were present by definition in all cases. Episodes of fever were reported in 30%, chiefly in the more severe cases. About 35% of the total farming population in all three areas complained of what they called "irritation" of the throat or nose during exposure to dust from mouldy hay, straw, or grain. This symptom subsided an hour or so after exposure ceased and was unrelated to the prevalence of farmer's lung. Radiological abnormalities (Table VI) were observed in

TABLE VI—Radiological Examination of Lungs

	Orkney	Ayrshire	East Lothian	Total
No. x-rayed	26	12	4	42
Micronodular shadowing	2	1	0	3
No abnormality	24	11	4	*39
No. not x-rayed	5	1	0	6

*Seven of this group (five in Orkney and two in Ayrshire) had micronodular shadowing when x-rayed previously.

only 3 of the 42 patients who were x-rayed. In seven others, however, micronodular shadowing typical of allergic alveolitis had been noted previously, during a more acute phase of the illness, and this had presumably cleared before the patients were x-rayed in the course of the survey.

Disturbances of pulmonary function (Table VII) were classified as "restrictive" when the FVC was more than 0.5 l. below the predicted normal value, and "obstructive" if the FEV₁/FVC ratio was less than 65%. On this basis a restrictive defect was present in 8 of the 43 patients for whom data were available, an obstructive defect in 12, and a combined restrictive and obstructive defect in three. Pulmonary function tests were normal, according to the criteria adopted, in the remaining 20 patients. A study of the smoking habits of the 43 patients showed that 16 (38%) smoked 10 g or more of tobacco per day,

TABLE VII—Pulmonary Function—Type of Defect

	Orkney	Ayrshire	East Lothian	Total
Restrictive	5	2	1	8
Obstructive	10	2	0	12
Restrictive + obstructive	2	1	0	3
None	9	8	3	20
Data not available	5	0	0	5
Total	31	13	4	48

mostly in the form of cigarettes, and that the number of smokers was proportionately higher in those with an obstructive defect of pulmonary function (60%) than in those with a "pure" restrictive defect (14%) or with normal function (29%). Although a mild degree of airways obstruction, contrary to earlier observations, is not uncommon in farmer's lung (Hapke *et al.*, 1968), this abnormality could have been caused by cigarette smoking in 7 of the 12 patients in this survey in whom it was recorded.

An F.L.H. precipitin test (Table VIII) was performed in 42 of the 48 cases. In 16 a positive result was reported on the specimen of serum obtained in the survey, and in two on a

TABLE VIII—Results of F.L.H. Precipitin Tests

	Orkney	Ayrshire	East Lothian	Total
Positive in survey	11	5	0	18 (43%)
Negative in survey but previously positive	2	0	0	
Negative	13	7	4	24 (57%)
No specimen obtained	5	1	0	
Total	31	13	4	48

specimen obtained a few months previously, during the acute phase of the illness, making a total of 18 (43%). The percentage of positive tests was similar in Orkney and Ayrshire, but the test was negative in all four East Lothian cases.

The occupational hazards believed to be responsible for the illness in the 48 cases are shown in Table IX. Dust emanating

TABLE IX—Nature of Occupational Hazard

	Mouldy Hay or Straw	Mouldy Grain	Both	Total
Orkney	20	5	6	31
Ayrshire	6	4	3	13
East Lothian	0	4	0	4
Total	26 (54%)	13 (27%)	9 (19%)	48

from mouldy hay or straw (usually hay) during the feeding of stock was incriminated in 54%, and the dust produced during the threshing or bruising of mouldy grain was the suspected hazard in 27%. In the remaining 19% both hazards seemed to be implicated. The main hazard in Orkney was mouldy hay or straw, and in East Lothian mouldy grain, while in Ayrshire both hazards seemed to be equally important. In the two Orkney islands of Stronsay and Sanday (Table X) the number of cases

TABLE X—Nature of Suspected Main Hazard in Orkney Cases

	Stronsay	Sanday	Total
Mouldy hay or straw (during feeding of cattle)	10	11 (+1)	21 (+1)
Mouldy grain/straw (usually oats) (during threshing, bruising, or milling)	7 (+4)	3 (+1)	10 (+5)

Numbers in parentheses indicate suspected additional hazard.

attributed to mouldy hay or straw was similar, but there was an excess of cases in Stronsay with a history of exposure to mouldy grain and this presumably contributed to the higher prevalence of farmer's lung in that island than in Sanday.

The pattern of the illness was influenced by the type of hazard to which the farmworker was predominantly exposed. Symptoms were present almost continuously in those who were mainly engaged in feeding stock with mouldy hay or straw, presumably because they inhaled large numbers of spores twice daily. In contrast, symptoms tended to occur intermittently in

those farmworkers who seldom handled mouldy hay, but who were often engaged in the threshing, bruising, or milling of a mouldy cereal crop, presumably because they were exposed to this hazard only once or twice a week. Some farmworkers were, of course, exposed to both types of hazard and presented a mixed picture of continuous symptoms with periodic exacerbations. In many cases there was a history suggestive of farmer's lung during previous winters, and it was indeed not uncommon for symptoms typical of this condition to recur every winter for several years.

The results of mycological investigation of sputum and environmental dust samples will be the subject of a separate communication.

Discussion

One of the most difficult problems which this type of survey presents is the definition of appropriate diagnostic criteria. It is superficially attractive to rely, as many workers have done in the past, on positive F.L.H. precipitin tests for this purpose, but such a policy is open to criticism (a) because patients with symptoms typical of farmer's lung may, for reasons discussed in the introduction, have a negative precipitin test, and (b) because a positive test may be recorded in farmworkers who have no respiratory symptoms (Pepys and Jenkins, 1965). If it is valid to reject a diagnosis of farmer's lung in a farmworker with a positive precipitin test on the grounds that he does not have appropriate respiratory symptoms, it must be equally valid not to reject this diagnosis in a patient with typical symptoms simply because he has a negative precipitin test. A positive test merely indicates that the farmworker has inhaled a large enough dose of antigen to produce detectable antibodies in the serum, and the diagnosis must in the final analysis be made on clinical criteria. It will, of course, be more secure if typical radiological changes are present in the lungs, or if there is evidence of decreased pulmonary compliance or of a reduction in TCO. These abnormalities are, however, observed only in the more severe cases, and if they are regarded as essential diagnostic criteria the prevalence of the disease will be seriously underestimated.

The routine use of provocation tests, in which body temperature, FVC, and TCO are measured before and after the inhalation of F.L.H. antigen, would no doubt contribute to more accurate diagnosis, but this is not a practical proposition in a large-scale field survey. Moreover, provocation tests are potentially fallacious, since a "positive" reaction might conceivably be provoked in a farmworker without overt symptoms of farmer's lung who has precipitating antibodies in his serum. It is therefore a reasonable assumption that the prevalence of farmer's lung will continue to be underestimated unless it is accepted that epidemiological surveys must for the present be based primarily on symptomatic criteria. Although complete accuracy in symptomatic diagnosis is unattainable, there is no doubt that standards could be improved and a substantial measure of uniformity achieved in epidemiological surveys by the adoption of a standard questionnaire. The Occupational Health Committee of the Medical Research Council has recently initiated discussions which it is hoped will lead to the production of a suitable questionnaire of this type.

The survey reported in this paper was based on symptomatic criteria. Although all suspected cases of farmer's lung were fully investigated along the lines already described, the final diagnosis relied primarily on the patient's symptoms and on their relation to the specific occupational hazards to which he (or she) was exposed. On this basis the prevalence of farmer's lung was estimated at 86 per 1,000 of the farming population in Orkney, 86 per 1,000 in Ayrshire, and 23 per 1,000 in East Lothian. These figures are all considerably higher than any previously reported in Britain, and since great care was taken to ensure that the farmer's lung symptom-complex was not confused with other respiratory diseases, such as chronic bron-

chitis and bronchial asthma, we believe that the prevalence rates recorded in the survey were broadly accurate within the limits imposed by necessarily crude diagnostic criteria. This impression has received some support from D. Parratt (personal communication, 1971), who tested sera from 25 of our farmworkers by a fluorescent antibody technique. He obtained a positive result in 16 out of 18 patients with symptomatic farmer's lung, and a negative result in six out of seven farmworkers in whom this diagnosis was rejected.

These results suggest that accuracy in the serological diagnosis of farmer's lung could perhaps be improved by the use of this technique to supplement the standard F.L.H. precipitin test. If, however, we accept the traditional view that the diagnosis of farmer's lung is valid only when the F.L.H. precipitin test is positive, the revised prevalence rates for Orkney (43 per 1,000) and Ayrshire (36 per 1,000) are still more than 20 times higher than any figure previously reported in Britain. On this evidence there can be little doubt that the prevalence of farmer's lung has so far been seriously underestimated. Because of regional differences, the actual size of the problem in Scotland as a whole is difficult to measure, but on the basis even of the lower prevalence rates we have calculated for Orkney and Ayrshire there must be no fewer than 275 cases in these two counties alone.

Other information obtained from the survey has enabled us to identify a number of factors which may influence the prevalence of farmer's lung, and to assess their importance. These can be summarized as follows:

RAINFALL

In the three areas included in the survey the prevalence of farmer's lung was directly related to the rainfall recorded during the previous summer, but the difference between the prevalence of farmer's lung in Ayrshire and East Lothian was greater than might have been expected from a comparison of the summer rainfall figures. This would suggest either that meteorological data other than rainfall (humidity, for example) would have been more relevant or that factors not directly related to climate at least partly accounted for the differences in prevalence between these two counties.

AGRICULTURAL PRACTICE

Most of the East Lothian farmworkers in the survey were employed on large arable farms, and few of them were regularly engaged in the feeding of stock. In Ayrshire, on the other hand, most of the farmworkers were employed on dairy farms, and the feeding of stock was one of their regular tasks during the winter months. This was also the case in the small mixed farms and crofts in Orkney. These differences in agricultural practice were no doubt partly responsible for the higher prevalence of farmer's lung in Ayrshire and Orkney than in East Lothian.

The agricultural industry in East Lothian is prosperous, and many of the farmers there can afford the expensive mechanical equipment required for the rapid drying of hay and cereal crops, both in the field and in storage. Since hay and grain with a low moisture content (below 20%) provide an unfavourable medium for the growth of fungi and actinomycetes, the economic advantages enjoyed by East Lothian farmers may have contributed considerably to the low prevalence of farmer's lung in that county. The smaller farms in Ayrshire are less favourably placed in this respect, and in Orkney the situation is a great deal worse, since many of the small farms possess no mechanical equipment, such as balers and binders, which may have to be borrowed from more fortunate neighbours. In these circumstances the farmers may have no option but to bale their hay and harvest their oats or barley at a time when the moisture content is undesirably high. In consequence, the hay bales and corn stacks often become

mouldy during storage, and give rise to a serious spore hazard when they are handled inside a farm building during the winter.

Conclusion

Although the pilot survey reported above was conducted on a relatively modest scale, it has shown beyond reasonable doubt that farmer's lung is an important occupational disease in certain areas of Scotland. It is clear, however, even from our limited experience, that much can be done to reduce the prevalence of this disease, or even to eliminate it completely. The measures which in our view can and should be taken to achieve this objective are as follows: (1) the promotion of an educational campaign to inform farmers and farmworkers of the nature of farmer's lung, and of what can be done to prevent it; (2) selective financial assistance for small farms, enabling the farmers to purchase equipment for the rapid and efficient drying of hay and cereal crops; (3) official propaganda, possibly backed by financial incentives, to encourage the use of silage, which carries an insignificant spore hazard, in preference to hay for the feeding of stock in small, ill-equipped farms; (4) encouragement of the provision of well-ventilated stock buildings and of mechanical systems for the handling and feeding of fodder, so as to minimize the dust hazard to which stockmen may be exposed; and (5) personal protection of farmworkers by efficient and comfortable respirators, which have been shown by Gourley and Braidwood (1971) to prevent a recurrence of symptoms in men with a history of farmer's lung when they are re-exposed to a heavy concentration of spores from mouldy hay; to be effective, these respirators must be worn continuously by all farmworkers whenever they are handling mouldy hay, straw, or grain.

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References

- Bjornsson, O. (1960). Personal communication to Dr. J. C. Gilson.
- Boyd, D. H. A. (1971). *Scottish Medical Journal*, **16**, 261.
- Campbell, J. M. (1932). *British Medical Journal*, **2**, 1143.
- Gourley, C. A., and Braidwood, G. D. (1971). *Transactions of the Society of Occupational Medicine*, **21**, 93.
- Hapke, E. J., Seal, R. M. E., Thomas, G. O., Hayes, M., and Meek, J. C. (1968). *Thorax*, **23**, 451.
- Medical Research Council (1966). *Questionnaire on Respiratory Symptoms*. London, M.R.C.
- Mindell, H. J. (1970). *Radiology*, **97**, 341.
- Ouchterlony, O. (1958). In *Progress in Allergy*, ed. P. Kallos, vol. 5, pp. 1-78, Basel, Karger.
- Pepys, J., and Jenkins, P. A. (1965). *Thorax*, **20**, 21.
- Pepys, J., Riddell, R. W., Citron, K. M., and Clayton, Y. M. (1962). *Thorax*, **17**, 366.
- Pepys, J., et al. (1963). *Lancet*, **2**, 607.
- Pickles, W. W. (1944). *Public Health (London)*, **58**, 2.
- Staines, F. H., and Forman, J. A. S. (1961). *Journal of the College of General Practitioners*, **4**, 351.
- Williams, J. V. (1963). *Thorax*, **18**, 182.