fleece has been removed the symptoms rapidly disappear and there may be few, if any, fresh cases that year.

The aetiology of the condition is still obscure. The short seasonal occurrence of the disease, the location of affected animals and the low morbidity have not encouraged any extensive research work. The classification of the disease as "rachitic" by some workers appears to be based on the similarity of the symptoms to those of other conditions. It is noteworthy, however, that ewes which become affected nurse the biggest lambs in the flock. The removal of the fleece may allow the actinic rays of the sun to penetrate to the skin of the animal and thus alleviate the negative calcium and phosphorus balance of a heavy lactation.

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Discussion

Professor S. J. Watson (Edinburgh and East of Scotland College of Agriculture, Edinburgh), opener: These two papers by Dr. Stewart and Dr. Dunlop demonstrate our lack of knowledge of the composition of grass and pasture. An extensive team is required for the study of this subject. When methods of analysis have been agreed, the work is just begun, and there is no final answer in analysis; we must know the availability of the constituents to animals. Again, a review of the literature shows that analyses do not agree; there are fluctuations in composition due to season and growth. Further, the composition when signs of disease appear may not represent the composition when the trouble began. There are also difficulties in getting representative samples. Sheep may not graze the whole of an area. Herbage that causes disease may not cause any when fed to stock elsewhere.

Then there is the question, what is a deficiency? In swayback, copper therapy is used, but there is no copper deficiency; in molybdenum excess, copper is curative but not deficient according to our inadequate standards. Diseases that occur on pasture most commonly affect the ruminant. Sufficient importance has not been attached to this fact. Has this association some connexion with the microflora of the rumen? Molybdenum, for instance, will stimulate the growth of certain strains of bacteria in the rumen. We know little about conditions in the rumen

and it would require a team of bacteriologists, zoologists, chemists and others to investigate the subject.

Dr. J. E. Nichols (Imperial Bureau of Animal Genetics, Edinburgh): I was specially interested in one of Dr. Stewart's points, the loss of condition when stock are turned on to fresh and highly nutritious grass because of the high moisture content of the pasture. I have been closely connected with work in Western Australia on cobalt and copper deficiency. In copper deficiency areas the grazing can be fresh and lush but the stock lose condition, with their appetites unsatisfied. Deficiency can follow on this semi-starvation, which can, however, be mitigated if the stock have at the same time access to rough scrub or old unlifted hay, which is eaten with the fresh grass and satisfies appetite. The management of stock in relation to grazing is as important as the minutiae of chemical analysis.

Mr. J. F. H. Chrisp (Low Trewhill, Thorpton, Morpeth): Dr. Dunlop stated that sheep affected with pine should be given 100 mg. cobalt four times during the months June to September. Would it not be possible to decrease the number of times the sheep must be dosed?

Mr. W. Watt (Ministry of Agriculture, Whitehall, London, S.W.1): If the total number of sheep in the phenothiazine tests was only 74, has anyone questioned the results on the grounds of the small number? Some farmers claimed great improvements from the use of phenothiazine.

Mr. J. A. More (Edinburgh and East of Scotland College of Agriculture, Edinburgh): A considerable amount of American work suggests that cod liver oil is harmful to sheep. Is this due to its vitamin content or to some other constituent? I should also like to know whether clover, fed over long periods, is harmful.

Mr. H. E. Harbour (Edinburgh and East of Scotland College of Agriculture, Edinburgh): Dr. Dunlop's phenothiazine figures would be more interesting if we knew the doses given. Hill sheep not infrequently suffer from severe infestations with *Trichostrongylus* sp. and these worms do not respond to phenothiazine in doses of 5 to 10 g. The small dose is certainly effective against *Haemonchus contortus*, but in Scotland we more often meet with infestations of the smaller stomach worms, and doses up to 15 to 20 g. are needed to control these.

Mr. A. L. Bacharach (Glaxo Laboratories, Ltd., Greenford, Middlesex): I wonder if the lambs classed by Dr. Dunlop as "free" from swayback, and showing a rather high content of lead in the liver, were killed at the same time as those that died of the disease, or whether they were older. If so, it is possible that they were continually accumulating lead in their livers at a time when it was no longer capable of doing so much damage as during embryonic or neonatal life. I was interested in his remarks about "bent leg". As cod liver oil has proved effective in its treatment, it would be interesting to know whether a solution of calciferol could achieve the same result. If not, then we should have to class lambs with chickens as two species of animals that can distinguish between the cholesterol and the ergosterol side chain in the course of a few days, a task that takes the organic chemist months or years!

Dr. J. Stewart replied: I should like first to refer to Dr. Dunlop's film. I should not like the medical people present to be given the idea that cobalt deficiency produces anaemia. Haemoglobin is not affected unless through some secondary cause such as parasitic infestation. Then Dr. Dunlop said cobalt was put on the hillside, sown with basic slag. We find basic manures with cobalt contra-indicated.

With regard to dosage with cobalt, Dr. Dunlop gave 100 mg. 4 times a year. It is better to give small doses frequently, say weekly, than larger doses less often. Cobalt must be given by mouth.

Phenothiazine is the most efficient anthelmintic on the market. I assumed Dr. Dunlop to mean that the worm burden in his sheep was so small that it did not affect the condition of the animal and this he tried to prove by giving phenothiazine.

Lead cannot be the sole causal factor of swayback. The ratio of copper to lead may be more important.

I agree with Professor Watson that a team of workers is needed to deal with these problems.

There is not enough cyanide in clover to produce poisoning. We have tested 150 samples. The amount of cyanide varies but is always too low to be harmful. Nor is cod liver oil necessarily harmful and vitamin A concentrates can be given in large quantities (100,000 I.U. within an hour of birth) without ill effect.

Dr. G. Dunlop replied: I agree with Professor Watson about the need for a team of specialist workers to investigate the many unsolved problems in these mineral deficiency conditions.

Supplementary cobalt is required on many grazings in the late summer and autumn, after the cobalt content of the herbage has reached its lowest seasonal level. On the sparsely populated hill grazings, for prevention of the gross symptoms depicted in the film, a dose of 100 mg. cobalt at the routine monthly summer gatherings has proved as efficient as the provision of mineral mixtures containing cobalt. In some flocks both treatments are now combined. Longer periods between the dosings have not been tried.

Phenothiazine was chosen as the most efficient anthelmintic and, as Dr. Stewart has inferred, the worm burden of the hill lambs in the experiment was so small as to have no effect on their liveweight increase. The total dose of 10 g. of phenothiazine, 5 g. at monthly intervals, was considered sufficient for the smaller lambs of 30 to 40 lb. liveweight in the experimental groups. As noted in the paper, the results were confirmed by other experiments on 12 farms in the College area involving 1000 animals. Some groups received as much as 20 g. phenothiazine per animal. The results of these experiments along with the statistical analysis of the results reported appear to indicate that the numbers were sufficient in the trial.

It has been shown by Cunningham (1944) that routine bluestone nicotine sulphate dosing controlled peat scours by correcting the copper deficient state of the animals and not a supposed helminthiasis. Substitution of phenothiazine for the bluestone anthelmintic under these conditions precipitates outbreaks of scouring.

With regard to the anaemic condition of cobalt deficient sheep the

caption in the film made it clear that only some animals show low haemoglobin values.

Basic slag applied to hill herbage encourages the growth of the sweeter grasses. Cobalt salt in solution is later sprayed over these areas and in this way sufficient consumption of cobalt rich herbage to meet the animals' requirement of the element is assured.

As was stressed in the paper a correlation between the lead content of pasture and swayback occurs in some areas only. In New Zealand and Australia the condition in most areas is one of pure copper deficiency. In other outbreaks analyses of the herbage may show neither a high lead content nor a low copper content but in many of these it is found that the pasture has been heavily limed.

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