

Mr. D. S. Rabagliati (Ministry of Agriculture, 3 St. Margarets Road, Edinburgh): The veterinary profession has not, in the past, taken as much interest as it might in animal nutrition. The study of nutrition is as important as the study of bacteria in the prevention and control of animal diseases.

## Pasture and its Dangers to Livestock

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### *The Composition of Pasture*

Ruskin in *Modern Painters* eulogizes grass in the following words: ". . . judge whether of all the gorgeous flowers that beam in the summer air, and of all strong and goodly trees pleasant to the eye or good for food—stately palm and pine, strong ash and oak, scented citron, burdened vine—there be any so deeply loved, by God so highly graced, as that narrow point of feeble green". Many of you, perhaps, quietly contemplating your well cut lawn on a summer evening might agree with him but those of us who have done any work on those aberrations of diet which cause disease must view grass with rather suspicious eyes because repeatedly we find that the cause of many of the maladies affecting livestock lies in the grass. This being the case it is all the more surprising that our knowledge of the exact chemical composition of grass is so slight and that so little interest is taken in it by agricultural research workers. A good example is the enigma of the Romney Marsh pastures where, on some fields, cattle will not fatten, while on neighbouring fields of apparently similar texture and quality, cattle fatten in a normal fashion. Many research workers have tried to solve this problem but all have failed, although various hypotheses have been advanced.

To the farmer the fattening quality of pasture is his main concern and yet, much more investigation is necessary even of those aspects pertaining to energy or nutritive value of pasture. Wood (1924), summarizing the data then available, declared the starch equivalent of grass to be 50 lb., and the digestible protein, 10 lb., per 100 lb. of dry matter. Only 2 years later Woodman, Blunt and Stewart (1926), in the first of a long series of papers on the nutritive value of pasture, showed that the starch equivalent of young grass was over 70 lb., and the digestible protein about 23 lb., per 100 lb. of dry matter; in other words, young grass was a concentrate comparable in value with linseed cake and, to a grass ration, carbohydrate and not protein should be added as supplement. This was a minor revolution in our thoughts on pasture and was, indeed, the scientific basis on which was based the suggestion of utilizing dried grass, grass cake and grass silage in winter rations. One would have thought that this would be the starting point for much intensive research into the chemical composition of grass, yet we still analyse pasture under the fractions, crude protein, ether extract, crude fibre, total ash and nitrogen free extractives. Surely such appellations must be anathema to a chemist's ingrained exactness. The nature of the crude protein is still obscure despite attempts to determine the amino-acid composition, and still less is known of the other nitrogenous substances. Recently at

Moredun it was shown that the non-protein nitrogen of pasture increased to a high value in the last week of May and beginning of June, fell to a minimum in August, and rose abruptly to a high value again in the beginning of September, but the substances represented in the non-protein nitrogen fraction of plants are unknown (Macpherson, 1943). Plant physiologists have shown that asparagine, glutamine and nitrates are important but these can only constitute a small proportion of the substances present. Chibnall (1939) has suggested the ammonium salts of the C<sub>4</sub>-dicarboxylic acids, fumaric, malic, and succinic, as "speculative possibilities" for the precursors of asparagine and glutamine.

Our knowledge is as scanty when we consider crude fibre and ether extract. The term nitrogen free extractives is supposed to represent the more soluble carbohydrates of the plant. The inaccuracy of its determination makes the value obtained of little real use since errors in the estimation of the other fractions are summed up in this fraction. It is indeed strange that we know so little regarding the carbohydrate fraction of grass when the fattening value of pasture is all important. Various workers have suggested probable carbohydrates as most likely to be found in pasture and recently the Agricultural Research Council have set up a unit of biochemists to carry out research into this problem. In addition to isolating the separate carbohydrates it is hoped that they will elaborate a suitable method for estimating them as a group so that we can have a much more reliable guide to the carbohydrate content of grass than nitrogen free extractives and crude fibre.

The importance of pasture in British systems of animal husbandry is fundamental. Nevertheless, as I have briefly tried to indicate, the study of pasture from the standpoint of chemical composition has been neglected and, although this is of importance as far as "feeding for fattening" is concerned, it is of greater importance when we consider grass as an aetiological factor in a large number of animal diseases.

#### *The Transition from Winter Feed*

Every farmer recognizes the dangers attendant on putting out his stock suddenly to grass in the early summer, a fall in milk yield during the first few days with accompanying scour. This is probably due to the greater water intake and upset of water balance in the body. The use of grass silage during winter months has decreased this loss of milk and also the initial loss of condition that usually goes with it. In sheep there are two diseases in which the condition of the pasture has a definite aetiological role. Pregnancy toxæmia is now thought to be due to dietary deficiencies which produce ketosis, and its incidence varies with season and weather conditions. Indeed, the conditions under which the disease occurs are so varied that it appears possible that several different, or apparently different, aetiological factors produce similar symptoms. "Pulpy kidney" disease in lambs is caused by *Cl. welchii* type D. Though the causal factor is a micro-organism, the diet of the lambs would appear to be of great importance in controlling its incidence. When it occurs in very young lambs the mother's milk is a controlling factor. In lambs 3 or 4 months old it is much more prevalent on a luxuriant growth of grass, and it is suggested that it is the high protein content of the grass which acts as a secondary causal agent. This was recognized by farmers

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long before the causal organism was isolated and much work (Stewart, 1929) was done to prove the condition to be due to high protein feeding *per se*. Although a high protein diet by itself will not cause the disease it would appear to set up ideal conditions for the growth of the organism or the production of its toxin. These two diseases illustrate the effect of an excess of richness in the pasture in either the protein component or some other still undetermined substance or substances.

#### *Diseases Involving Mineral Metabolism*

Diseases resulting from deficiency of trace elements are now receiving considerable attention. Much work has already been done, and much more must be done before we can understand the true significance of the role of these trace elements and before each can be placed in its true perspective with regard to the others. It is in the study of these diseases that we realize our ignorance of the conditions affecting the composition of pasture. Although some of the trace elements, in either deficiency or excess, produce diseases in plants, others appear to play no part in plant physiology but do play an important role in animal physiology. We are still unaware why one species of grass appears to assimilate more cobalt than another or why manuring to increase the content of one trace element increases the content of others. There are countless other problems needing elucidation from both the plant and animal point of view.

#### *Cobalt Deficiency*

We now know that over large areas of Scotland the pasture is deficient in cobalt. On such pasture young lambs show progressive debility associated with emaciation and are said to pine. Since this is a symptom common to many diseases it would be better to call the condition "cobalt deficiency disease" rather than "pine". It can be prevented by top dressing the grassland with cobalt at the rate of 2 lb. cobalt sulphate per acre (Stewart, Mitchell and Stewart, 1941). This procedure is now in common use in the north of Scotland. Farmers are advised to make sure that the pine on their farms is due to cobalt deficiency before starting to use cobalt top dressings, since it has been shown that the molybdenum content of pastures can be increased by the use of cobalt salts. It is worthy of record that on one farm in the cobalt deficient area of Easter Ross we have shown that the pining occurring in calves is due to excess molybdenum in the herbage similar to that of the "teart" pastures of Somerset. The molybdenum content of the pasture is not as high as that of the "teart" areas and that is probably why the disease is not so prevalent. It can be cured by feeding copper in a similar fashion to that advised for "teart". The interrelationship of copper and molybdenum in the plant and animal, and possibly in the soil, is a complicated problem.

#### *Copper Deficiency*

A disease of lambs which was very prevalent in Scotland in 1943 was "swayback". This is a nervous disorder of newborn lambs of which the outstanding symptom is ataxia. Its cause is at present unknown but is in some way linked with trace element deficiency or excess, since the

administration of small amounts of copper throughout gestation prevents the disorder in the lambs. In Australia a very similar, if not identical, condition known as "enzootic ataxia" has been shown to be due to copper deficiency but in Britain "swayback" is not considered to be due to copper deficiency *per se*, since it usually occurs on farms where the copper content of the grass and soil is normal. In an investigation of the outbreaks in Scotland in 1943, workers at the Macaulay Institute, who were collaborating with us, showed that in one area the copper content of the pasture was very low. These results are probably the first in this country to be correlated with those of Australian workers. Shearer and McDougall (1944) have emphasized that the data so far obtained in this country would not have suggested a copper deficiency had it not been indicated from the Australian work. In two other areas investigated by us in 1943, there was no indication of a copper deficiency. It would appear that there is another factor which must be of aetiological significance. A theory which has found favour with some workers is that the presence of an excess of lead may be the other factor involved. Work done at the Moredun and Macaulay Institutes in 1943 would point rather to an upset in the ratio of copper to lead but much work is necessary before any definite conclusion can be drawn.

#### *Calcium and Phosphorus Deficiency*

In addition to diseases due to trace element deficiencies there are also diseases due to deficiency of major elements. Apart from sheer poverty of herbage there are many areas in Scotland where animals suffer from mineral, usually calcium and phosphorus, deficiency, or mineral imbalance. A year or so ago we had reported to us a condition in cattle very similar to the "aphosphorosis" described by Theiler and Green (1932) in South Africa. Highland cattle grazing on hill land rising from the sea wandered repeatedly on to the seashore and gnawed bones and even sea shells. When mineral mixtures were first given there was a stampede to reach the boxes and the health of the animals improved.

Mineral deficiency is shown in the animal by loss of condition, depraved appetite and various types of osteomalacia. "Classical rickets" has never to my knowledge been reported in cattle or sheep in this country. In parts of Northumberland the mineral content of the pasture is such that sheep exist in a state of hypocalcaemia, the blood calcium being 15 to 20 per cent. less than the normal for the rest of the country (Shearer and Stewart, 1931). The phosphorus content of the blood also is below normal. There is no obvious clinical symptom specific to this condition except that the sheep are always "poor doers" and would appear very susceptible to bacterial infections, probably because of their poor condition. The feeding of a mineral mixture raises the blood composition to normal values. This can be done also by improving the grassland over a small area and allowing ewes and lambs access to this area in rotation. The raising of the blood minerals has a highly beneficial effect on the health of the stock. Another interesting condition is a disease called "double scap" or "cappi". This disease is known in many parts of the country and under various names. Farmers recognize it by a raising of the frontal bone and believe it can be cured by pressing this bone back to its original position; very often the bone is cracked as

a result. The condition is really a generalized osteoporosis and is evident even in the long bones. Analysis of bones, blood and pasture revealed that the deficiency was of phosphorus rather than of calcium (Bosworth and Stewart, 1933). Attempts were made to reproduce the bone condition by feeding diets low in phosphorus. The clinical condition as far as the frontal bone was concerned was not reproduced but analysis showed the chemical composition of the bones to be similar to that of the natural cases of "cappi" (Stewart, 1935). So many factors are involved in the absorption of minerals from the intestines and in the deposition of bone that it is difficult to make experimental conditions identical with the natural.

### *Magnesium Deficiency*

A disease of cows which is prevalent over quite a large area of Scotland is "lactation tetany" or "grass tetany". The term "lactation tetany" is a misnomer since cases have been reported in bullocks and maiden heifers. Death occurs suddenly in many cases without previous symptoms. If one death focuses the farmer's attention on his herd he may notice slight nervous symptoms in a few other animals. Blood examination of cases revealed a very low magnesium content and a slight reduction in the calcium content. If the blood of the whole herd was sampled after one case had been reported, usually about 50 per cent. showed a reduced blood magnesium content (Blakemore and Stewart, 1933, 1935). The condition could not be correlated with the magnesium content of the pasture which was normal. It would appear to be caused by some constituent of the herbage which interferes with magnesium metabolism. The feeding of mineral mixtures high in magnesium prevents the disease. On farms on which lactation tetany is prevalent there is a seasonal fluctuation in the blood magnesium of cows; this may coincide with a seasonal fluctuation in some unknown factor in the pasture. Research continues along the lines of trying to establish the unknown factor.

### *Clover Sickness and Grass Sickness*

There are two diseases of horses in which pasture would appear to play an aetiological role. The first is "clover sickness". At the height of summer when clover is in bloom in certain areas will exhibit symptoms which appear similar to anaphylactic shock, oedema of the muzzle, due possibly to photosensitization, scouring and loss of condition. If the condition becomes aggravated a type of mania appears and the animal dies in great distress but this occurs only in a few cases. Little is known about the condition but the cause is usually attributed to the protein of the clover. As the incidence varies greatly from year to year it is not known whether it is the character or the amount of the protein that is the causal factor. "Is the protein of clover different from that of grasses"? seems to be a question that needs an answer.

The second disease of horses is "grass sickness". This disease has its greatest incidence at the end of May and beginning of June, and usually about 14 days after horses have been put to grass. At this time of year pasture is at its most luxuriant stage of growth, and most cases occur on well manured arable grassland, though it is also known on sparse herbage, and, on rare occasions, in horses fed on hay and oats in stables. The

cause of the disease is still unknown and even if it should be found to be an infective agent it would appear that the composition of the grass has an important role in the aetiology of the disease. The diet of stabled horses is usually rich in carbohydrate and there is need for investigation into the physiological changes that take place when they are suddenly switched from a limited quantity of a carbohydrate rich diet to unlimited grazing on pasture.

The diseases I have mentioned are those most prevalent in Scotland. Most farmers have at some time to pay heed to the potential dangers of their pastures as far as livestock is concerned.

I have tried to stress our lack of knowledge of the chemical composition of pasture and of its variation under differing soil and weather conditions. I have tried to stress how the chemical composition of pasture may play a causal or major role in the aetiology of many animal diseases and how, if we are to elaborate preventive or curative measures, our knowledge of pasture must be extended.

There is, therefore, real and immediate need for the formation of a group of experienced organic chemists and plant physiologists to work in close collaboration with soil chemists and nutrition and disease research workers, and it is hoped that in the near future a research institute or agricultural college will bring such a team together.

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## Mineral Deficiency Conditions in Sheep on Scottish Hill Grazings

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### *Cobalt*

The film "Vinquish in Hill Sheep" is presented to depict various aspects of a cobalt deficiency disease in 44 south Ayrshire hill flocks (Dunlop and McCallien, 1941). The earliest reference to the condition in this area is that of Aiton (1811), although Hogg (1807) had previously observed that it was confined, at that time, to the west of Scotland where it was distinguished in different shires by the names of "pining," "daising" and "vinquish".

The following symptoms as they occur in ewes and lambs are shown in the film: emaciation, rough staring fleeces, watering eyes, anaemic