DANGER OF IMBALANCE IN ANIMAL NUTRITION.

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MY 'contribution is in the main suggestive, and, I hope; provocative in a constructive sense. It contains little that is concrete save certain established facts of animal physiology and pathology. As a student of scientific endeavour, I have the greatest admiration for the workers who have made, such phenomenal progress and have more or less revolutionized older views as to 'the productive capacity of the land. Most' of this- valuable work on the use of 'fertilizers, cultivation, and. plant-breeding has been done within the past 'ten or fifteen years, and the practical results are everywhere -apparent, and still research continues and further far-reaching. improvements are within sight.

However, as an animal physiologist and pathologist, my admiration .is tempered with doubts in some directions, since one cannot but notice that coincident . with the amazing improvement in quantity and quality of crops there has sprung up a whole series of new and perplexing problems. of animal health which appear to be of nutritional origin. The diseases themselves are not altogether new, but from the position of perplexing rarities their incidence has increased to the extent that they are now of major economic importance.

Before entering the realms of hypothesis it may be well to mention two or three well-established instances of the ill effects of imbalance in nutrition. Probably the most widely known are deficiencies of the nutritionally essential amino-acids-cystine, hjstidine, lysine, and tryptophane. Certain proteins do not contain all of these ingredients in their make-up-e.g., experimental animals whose sole source of protein is zein of maize fail to survive. Other proteins—e.g., gliadin of wheat-suffice to maintain life, but fail to permit normal growth owing to their low lysine content.

Another instance is the condition of osteoporosis-enlargement and softening of the bones-in horses as a result of heavy bran-feeding. Bran contains 0·2 per cent. CaO 'and 2·8 per cent. P_2O_5. Formerly this condition was attributed to a calcium deficiency in the ration, but in the light of recent work, which indicates a high efficiency of calcium utilization, this condition in horses is now accepted as due to an unbalanced ratio between the calcium and the phosphorus.

Constipation and indigestion, or diarrhœa following a sudden change from succulent to dry fodder and vice *versa*, may also in a way be attributed to a lack of balance in feeding, and are familiar to all. In 'such cases, however, unless extreme, the animal accommodates itself in time to the change.

Bcforc turning to possible but unestablished instances of nutritional imbalance following on the striking improvements of grass-land, I wish to make a plea for greater consideration to be given to the question of palatability. It is a striking feature of some of the strains of New Zealand certified rye-grass that stock do

not relish its herbage and do not eat it so long as any other is available. Nutrition cannot be regarded entirely in terms of calories and chemistry : there is undoubtedly a psychological aspect. An appetizing meal is 'an encouragement to eat to capacity—a highly desirable trait in a heavy-yielding dairy cow, for instance. On the other hand, an unpalatable meal is not consumed beyond the satisfaction of the hunger craving; in other. words, it tends to be consumed only in sufficient quantities to satisfy the individual's maintenance requirements.

An example of the importance of palatability which comes to mind refers to a top-dressing trial of which I saw something some few years since. The trial was designed to ascertain the benefit of potash 'manuring superimposed upon phosphatic manuring. The experimental paddock was accordingly top-dressed with superphosphate, and half of it received an additional dressing of potash. According to the accepted criteria-viz., naked-eye observations plus weight of crop produced-there was no discernible difference whatever in favour of the potash. Yet when the cows were turned into the, aftermath they kept the potash-dressed half of the paddock closely grazed, whilst the other half, which had received only phosphate, " ran away " to a second crop of seed-heads. I have seen other similar instances, and to my mind they constitute a strong case for greater consideration being given 'to qualitative results rather than the present tendency to concentrate on quantity to the exclusion of everything else.

From a consideration of the palatability of the herbage one is led to consider the quality of the produce of that herbage.

The question arises as to whether the " perennial rye-grass-white-clover " combination is under all circumstances the ideal raw material from which to produce the finest quality meat and wool.

In Great Britain the superior quality of Scottish and Welsh mountain mutton cannot be gainsaid, and it commands. a large premium in the Smithfield market. In New Zealand the finest mutton is that from the high-country runs in the South Island. The difference is not entirely one of breed, since those same animals brought down as stores to richer lowland grazings do not eventually produce the same super-quality mutton.

Because the allegedly inferior grasses produce a relatively small proportion of the total herbagc, there is a tendency to dismiss them as of no economic importance, despite the fact that stock frequently exhibit a decided preference for them. It may be that they are not quite so ineligible and unworthy' of a place in the pasture as appears at first sight. It cannot be gainsaid that a small percentage of salt makes a world of difference to one's porridge or breakfast egg, and the same may apply to some of the herbage species at present despised.

When mineral licks first became the vogue in Australia, flock-masters who produced the superfine grades of merino wool found that the consumption of lick resulted in a considerable lowering of their wool count. The heavier weight of wool produced did not offset the lower price secured for the stronger wool. In other words, quantity at the sacrifice of quality may not always be economic.

To quote one more example : Dairy-factory managers state that when making competition butter and cheese they always select the milk from that supplier with the poorest and least improved pasture. We still have complaints regarding the inferior quality of our dairy-produce, and it is conceivable that they may be due in many instances not to bacterial contamination and faulty manufacture, but to inherent weaknesses of the raw material.

I suggest, therefore, that it might pay to give a little attention to the possibilities of quality as distinct from mere quantity, and to consider and experiment in a small way in the direction of producing a herbage which may serve to enhance the quality of our produce.

To turn now to the more hypothetical cases of imbalance in nutrition-I use the term hypothetical in the sense of unproven rather than imaginary-there is the incidence of milk fever in different districts in New Zealand. Dr. Hopkirk has already briefly touched on this particular subject and indicated that a constant symptom is a temporary drop in the calcium-level of the blood. This disease is one of the great bugbears of the Waikato dairy-farmer. Almost every farm is equipped with the necessary apparatus to alleviate the condition. In Taranaki, on the other hand, milk fever is quite a rare condition. When the Taranaki farmer does experience a case he is puzzled and greatly alarmed. It is interesting to compare the average spring pasture in the two districts : Taranaki (37 samples), CaO 1·19 per cent., P_2O_5 0·87 per cent. ; Waikato (16 samples), CaO 0·91 per cent., P_2O_5 0·86 per cent. The Taranaki values for calcium are extraordinarily and consistently high ; in fact, as a representative average, they are considerably higher than any average value I have seen reported in the literature. On the other hand, the Waikato average is not in any sense low, and unless one can postulate some other predisposing factor it becomes difficult to accept the view that the high incidence of milk fever is associated with an insufficiency of calcium in the food-supply. It is possible that the clue to the other predisposing factor lies in the very wide ratio between potassium and sodium in highly fertilized pasture during the flush period of growth. Sjollema, in Holland, commenting on the great increase in the incidence of milk fever and grass tetany, correlates the increase with alterations in the feeding and fertilizing practice which result in stock consuming excessive amounts of young, rapidly growing grass. Such pasture has an extremely high potash content. Analyses show that the potash is often in excess of 3 per cent., and may reach as high as 4 per cent. Sodium, on the other hand, ranged between 0·1 per cent. and 0-2 per cent. He suggests that the potash, which occurs chiefly as the nitrate, is during the digestive process partially converted into nitrite, which is toxic. He also states that excess quantities of potash in the ration interferes with the absorption of calcium. Godden and others, at the Rowett Institute, have confirmed the latter fact in metabolism experiments on pigs. They found that excess of potash has a distinct depressing influence on the retention of both calcium and phosphorus, and that the addition of sodium to the ration assisted in increasing the calcium retention.

Such figures as are available show that the range of potash in top-dressed New Zealand pastures during the spring flush of growth is almost invariably in excess of 3 per cent. It has also been established by several workers and confirmed in New Zealand that the potash-level is always at its peak when calcium is at its lowest, and vice versa. There is little data available on the sodium content of New Zealand herbage, but it has been established elsewhere that the pasture in coastal districts has a considerably higher sodium content than has that from inland districts. In the light of Sjollema's and Godden's work it seems likely that the explanation of the differences in the incidence of milk fever (and possibly also grass tetany) between the Waikato and the Taranaki districts lies in the predisposing influence exercised by the potash-sodium ratio on calcium retention, since the sodium content of Taranaki herbage will almost certainly be considerably higher than that in the Waikato.

Another trend in the modern development of pasture improvement which seems fraught with potential danger is the positive correlation which has been established between the more prolific clover-strains and their content of hydrocyanic acid (HCN). The minimum lethal dose of this substance for a horse or an 'ox is' 5 to 6 grs. (325–390 m.g.m.). The HCN content of grass ranges from 0·0001 per cent. to 0·0005 per cent. on a fresh-weight basis. Thus an animal consuming 100 lb. of grass per day would have a total intake of just under 50 m.g.m. HCN. However, some of the "best" strains of perennial white clover have an HCN content in excess of 0·013 per cent. On a similar consumption of fresh clover a beast would take in approximately 6,000 m.g.m. of HCN. Even assuming that the animal ate uniformly throughout the twenty-four hours, it would consume very nearly the minimum lethal dose every hour.

The exact process by which cyanogenctic glucosides are broken down during digestion is a problem that still awaits solution, but it is quite definitely established that other leguminous plants are highly toxic for stock. I am aware that a limited amount of investigation has already taken place in connection with the possible toxicity of these clover strains, but with negative results. However, I think much more work should be done in this direction, particularly as regards "bloat," which is so prevalent during periods of flush growth. Fermentation with the production of large amounts of CO, and CH, is a perfectly normal process during ruminant digestion. In the ordinary way the animal belches up the gas at frequent intervals without it having any opportunity to accumulate. The question arises, therefore, as to why the bloated animal suddenly fails to rid itself of the gases in the ordinary way. A study of the physiologppf the various organs is suggestive, since the motor-nerve supply of both the rumen and the œsophagus is derived from the vagus nerve. This nerve also sends motor fibres to the mechanism which controls respiration and inhibitory fibres to the heart. It arises from the medulla oblongata-a portion of the hind brain which contains the respiratory centre. Hydrocyanic acid exerts its specific action upon the medulla, causing paralysis after a short preliminary period of excitement. When one considers the extraordinarily sudden onset of cases of bloat, the above facts are at least suggestive, and it is a line of approach which will merit further investigation than it has received.

I have reserved to the end a consideration of what is undoubtedly the most serious problem of all those of nutritional imbalance-viz., the' phenomenally 'high protein-level of heavily fertilized pasture in New Zealand. The widespread pathological effects of this abnormal herbage on the animal organism are only beginning to be dimly realized, but I believe that when the ground has been fully, explored they will prove, to be of so far-reaching a nature that as their economic effects come. to be fully realized their gravity will force serious attention,& the search for suitable means of correction. A table of values is illuminating :—

		Percentage of Nitrogen.		X 6·25 =	Percentage of Protein.
J. B. Orr, "Minerals in Pastures"	Island of Lewis		1·34		8·37
	Falkland Island		1·03		6.44
	Cultivated British pastures	(48)	2·83		17·69
Lambing percentage over 90 in all cases	Lord Astor's racehorse-paddock		3·56		22·25
	Poor Southland sheep-pastures	(30)	2·60		16.25
	Poor Taranaki sheep-pastures	(15)	3·20		20·00
	Poor Waikato sheep-pastures	(10)	3·61		22·56
	Southland pastures	(45)	3·17		19·81
	Nelson pastures	(50)	3'59		22'44
	King-country	(28)	3·40		21'15
	Wairarapa cow-paddocks	(18)	4·27		26.69
	Taranaki cow-paddocks	(48)	4·14		25.87
	Waikato cow-paddocks	(223)	4·81		30.06
	Marton Experimental area	(60)	4·76		29'75
	Marton Experimental area (highest)		5·48		34'25
	Waikato cow-paddocks (highest)		6·15		38.44

('All samples were taken during spring period of flush growth.)
(Figures in parentheses indicate the number of samples arranged,)

A perusal of the above figures reveals the fact that only the poor Southland sheep-pastures are comparable with the standard quoted by Orr for good English pastures, and that with four exceptions all the above New Zealand averages are above what Orr considers an exceptionally high value. Sjollema, reporting on exceptionally rich Dutch pastures, notes that in exceptional circumstances the protein content may approach 30 per cent.

It is common knowledge that protein is relatively indigestible, and many of its degradation products are decidedly toxic in character unless promptly excreted. The mature animal requires only relatively small amounts of protein for maintenance, and even for production—e.g., of milk-the requirements are not high. It is accepted that on good English pasture a dairy cow can satisfy all her requirements comfortably even for heavy production. However, a 10 cwt. cow in New Zealand producing 3 gallons of milk a day has to consume almost three times as much protein as she requires, assuming a 30-per-cent.-protein content in the pasture (the content of other nutrients does not differ so markedly from the accepted standards). For maintenance purposes only-e.g., dry stock or herd sires-the excess of protein is much greater. A bull weighing 16 cwt. perforce consumes some 10 lb. of protein-a day, when his maintenance-requirements may be satisfied by about 1½ lb. The same holds good for sheep-particularly breeding-ewes-which on the better pastures may have to consume eight or ten times as much protein as suffices for their requirements.

It is obvious, therefore, that stock on highly improved New Zealand pastures have to consume. excessive quantities of protein. What ill effects are attributable to this ? In the first place, it is probable that- a great deal of male sterility is caused by excessive protein-consumption. Numerous workers have demonstrated that there is an optimum protein-level for fertility both in the male and female, and that rations deficient in, or containing excessive amounts of, protein result in a decrease in fertility. The type of protein itself is also of importance. Proteins deficient in lysine, one of the essential amino-acids, leads to under-development of the testicles. Cunningham, at Wallaccville, has demonstrated that a high-protein diet causes complete sterility, in male, rats, although females on the same diet retain their fertility. Sterility in dairy bulls is a major problem in New Zealand, or, at any rate, in the North Island, 'and it seems a significant fact that it is much more prevalent in the Waikato and Auckland districts than in those farther south. This incidence correlates with the average protein-level of, the pastures in the different districts. In southern dairying districts male sterility is, relatively speaking, uncommon. A further highly suggestive point is that the microscopic picture of the degenerative changes which occur is practically a parallel with those occurring in Cunningham's experimental rats.

More recently attention has been focussed on the problem of sterility in rams. The average sheep--farmer, in view of the -system of -breeding adopted, has little or no idea of the fertility of individual rams. On the other hand, the stud breeder who is " hand-serving " his ewes and keeping accurate records is only too well aware of the extraordinary number of failures. The problem is a major one. During the past season fifteen z-tooth rams, to outward appearance normal in every respect, were selected at random and used for experimental breeding ; three proved completely infertile, four were practically so, and only five (33 per cent.) could be classified as thoroughly fertile. It is significant to note that these sheep had been reared on particularly rich pasture. A further significant feature is that the incidence of ram-sterility is apparently much greater in the North Island than in the South.

To turn from the ram to the ewe, on the richer sheep grazings in New Zealand the losses from what are termed pregnancy-toxæmias in breeding-ewes are staggering. On some properties these losses may aggregate up to 10 per cent. of the ewe flock in a bad season. The disease is popularly known- as sleepy sickness. Ewes occasionally, and dairy cows not infrequently, particularly in the Waikato, are afflicted with--a condition known as eclampsia, of which nervous- -excitement is a prominent symptom. Redwater (blood in the urine), when occurring in dairy cows on' spring grass, is yet another condition possibly attributable to the high protein diet. Pregnancy throws ,a considerable 'extra strain on the system, particularly on the -excretory organs—viz., the liver and kidneys-which are responsible for eliminating the end products of protein-metabolism. When these excretory organs are already overtaxed the additional strain thrown upon them in dealing with the excretory products of the fœtus as well may frequently lead to serious and even irreparable damage. The pathological changes--particularly in the liver-are very common in ewes.

A tremendous amount of research has been carried out by the medical profession on the subject of pregnancy toxæmias, and it is now generally accepted in human practice that excessive protein is definitely dangerous, and that the protein-level of the diet should bc reduced during pregnancy: Warnekros and Hinselman have published very extensive data showing that in Germany and Austria during the Great War human eclampsia showed a remarkable fall in its incidence-particularly in the two later years, when meat was scarce and drastically rationed. After the war, when supplies became normal again, the incidence of maternal eclampsia returned to its pre-war level. Sleepy sickness of ewes, which is characterized by a toxic degeneration of the liver, is one of the major problems of the North Island sheep-farmer on better country. It appears to be relatively rare in the South Island and on the high-country runs is practically non-existent. Incidentally, this fact teaches a moral : Nature designed the sheep as an upland dweller to seek and thrive upon the sparse herbagc gleaned from the hill-tops. The high protein and low fibre content of rich pasture may probably be at the bottom of other diseases of sheep, such as "bearing trouble" and "antepartum paralysis." The low fibre content provides insufficient bulk to stimulate the bowels to normal peristaltic activity, with the result that greater opportunity is afforded for the absorption of toxic degradation products of protein catabolism.

Gill has suggested a somewhat similar process as a possible factor predisposing to pulpy kidney, and he recorded that on farms where losses were occurring rye-grass constituted in the vicinity of 50 per cent. of the available herbage, whilst on unaffected farms the perennial rye-grass content was under 20 per cent. Levy, in reporting on these arms, suggested that it appeared to be a factor of quality rather than quantity.

A final suggestion I wish to offer is the possibility of silage made from high protein pastures being responsible for much digestive trouble occurring in dairy cows during the winter. A condition known as acidosis or acetonæmia—characterized by an upset of the acid-base equilibrium of the body-is becoming decidedly prevalent. Excessive amounts of organic acids and of nitrites and other degeneration products of protein which are produced during the ensilage process may conceivably bc the causal agents.

This paper is already overlong, and time will not permit me to touch on any further possibilities. The cases I have mentioned are, as I said in opening, mainly hypotheses based on analogies, but any or all of them offer urgent problems for research, and such evidence as I have been able to bring forward is, I believe, strongly suggestive of the fact that the striking improvement in grassland management appears to have . . brought in its train formidable problems of imbalance in animal nutrition. The provision of adequate research facilities is urgently necessary, as is the close co-operation of the grassland specialist with the physiologist and the biochemist. Progress must be co-ordinated lest it defeat its own ends.

Discussion on the Papers by Dr. Hopkirk and Mr. Webster.

Mr. Cockuyne : **The increase in production on our farms has led to a whole variety of difficulties, and the suggestion is thrown out that the avoidance of these difficulties can come about by production not being maintained at the stage it is but going back to the stage it was. I was pleased that Mr. Webster paid**

particular attention to the remarkable amount of protein that our stock are consuming as disclosed in the session on feed flavours in dairy-produce. With regard to HCN in clover,. where No. 1 white clover is the dominant constituent of the herbage, there must have been a number of cows that consumed in the twenty-four hours well over 100 lb. to 150 lb. of No. 1 white clover and of the highest HCN content that we know in white clover, and they have not died of HCN poisoning.

Mr. *Napier* : Relative to Mr. Webster's paper, potassic fertilizers used in this country carry considerable variations of sodium chloride, ranging from 30 per cent. in general use to 60 per cent. Probably from 160,000 acres to 170,000 acres only of New Zealand pasture was top-dressed with potash in 1935–36. Approximately 2,500,000 acres are top-dressed annually. It is not to be supposed that milk-fever occurs only on top-dressed areas.

Mr. Scott : Both Dr. Hopkirk and Mr. Webster have indicated that many of their contentions were hypothetical, and as such they have considerable value. Management is often of greatest importance. Sterility in animals, while it is experimentally attributed to excess protein, is sometimes caused by excess condition, especially in pigs on a low protein diet. Importance may attach to the artificial circumstances under which the animal exists.

Mr. Ballinger : Regarding work done in Canterbury. Agricultural College, pigs in pregnancy get sleepy sickness badly. If we control the condition of our animal in the autumn and feed it with a decent diet through the winter, sleepy sickness disappears. With regard to sodium, it is found in Marlborough and at Ashburton, as you go in from the sea, so are sheep more -inclined to eat more salt.

Mr. Doak : He the correlation of the incidence of bloat with the content of hydrocyanic acid, both red clover and lucerne are known to cause bloat, vet neither of them contain hydrocyanic acid. Succulent rye-grass has been known to cause bloat, and there is virtually no HCN in that.

Dr. Askew : As far as I am aware, until you get greatly increased amounts of potash, there is no definite evidence that potash contained in the food affects the calcium very much. In. ordinary pastures the sodium content is low. It is not correct to say that coastal pastures contain more sodium -than inland ones. I would suggest Mr. Webster may be able to persuade people to try a little more salt in the way of lick where they are having difficulty and where the potash may be too high. If high protein in grass causes the result suggested in the paper, more hay used in the spring as well as the winter should assist greatly. The position has been reached when we know much of the chemical composition of pastures, but we do not know what is the effect of intensive fertilizing on the class of compound present in the grass. Take nitrogen. How is the proportion of nitrates, &c., affected under intensive grazing ? That should be cleared up by chemical analysis. The effect of minerals on stock-products and the possibility of their affecting quality is a question worth investigating.

Professor Peren : We are proceeding in an unbalanced way in this country. Our pasture-development and carrying-capacities have gone up by leaps and bounds, but the other side of the work-that aspect relating to the reaction of stock to these totally different pastures-has been neglected. The time is long overdue when a much more determined attack should be made on the problems arising out of this new state of affairs.

Mr. *Montgomery* : Regarding the suggestion that high protein content may bring- in stock troubles, one of them being grass staggers, a point coming out of overseas work was that it was the young, rapidly growing grass that was taking up the raw materials quickly and not elaborating them at the same rate that was likely to cause the problem, and that one of the solutions of the problem was to allow the grass coming away rapidly in the early spring to bc somewhat mature, rather than to feed *it* to cattle while it was in the 2 in. and 3 in. stage.

Mr. Webster : Mr. President, you rather inferred that I had suggested it might be advisable to go back. I did not suggest that any retrograde step was advisable; we must continue to progress. As regards hydrocyanic content of herbage, one detail is that there is a very vast difference between a lethal dose and a toxic dose. In my remarks regarding hydrocyanic acid I was suggesting the

intoxication as distinct from poisoning-varying degrees of intoxication producing partial paralysis of a nerve, which is quite a distinct thing from death. Mr. Napier raised the point of the potash-sodium ratio. I was not referring to potash top-dressing. Mr. Scott raised the question of sterility due to obesity and lack of exercise, and Mr. Ballinger raised the possibility of it being a genetical factor. Obesity and lack of exercise arc very well established as causes of male sterility under certain well-defined circumstances which obviously do not apply in New Zealand, except possibly in the case of the pig. It may apply to stud animals. which, are being got up for showing conditions and become very fat. As 'regards the potentialities of the genetic inheritance of infertility, that is well 'established. We have examples in Australia in some of the Merino flocks where they have inbred continuously, but under New Zealand conditions there is, if anything, a lack of inbreeding. In sleepy sickness there is a great deal more than high protein content of the diet. Sleepy sickness is immediately associated with a fall 'in nutrition-sheep are going back in condition at the, time the symptoms arise, but the symptoms are only a culmination of a' series of predisposing factors; and the most important is excess of protein.