THE ANIMAL AS A MEANS OF MEASURING THE NUTRITIVE VALUE OF PASTURES.

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There is no need to point out to a meeting of this Association the great economic importance, particularly to New Zealand, of pasture grass, nor to refer to the advances that have been made in the management of grasses in their utilisation as food for domestic stock.

The evolution of this highly nutritious fodder has been the result of combined researches in the fields of plant genetics, agrostology, agricultural chemistry, and animal nutrition. Special methods of experimentation have had to be devised in each field so that necessary information might be available for the direction of further effort, and it is my purpose to describe those in which the animal itself has been used directly to measure the nutritive properties of pasture grass.

The earlier investigations of the alimentary needs of animals started by Humphrey Davy and advanced in the hands of various workers such as Liebig, Lawes and Gilbert, Kellner Armsby tc our present-day workers provide accurate data regarding the energy and production requirements in terms of proteins, fats and carbohydrates. When to this is added the recent conceptions and proof of the extreme importance of mineral elements and of vitamins to physiological well being it becomes almost possible to conceive that food values may be expressed largely in terms of the chemical constitution of the food material. In spite of the advances made, however, the final conclusion as to the efficacy of. any food mixture can be reached only after direct appeal to the animal.

In the particular case of pastures the importance of such direct appeal will be evident from examples of grave disorders that result from the consumption of what are apparently, in a chemical. sense, excellent foods. First, grass staggers of dairy cows is a disease which occurs in many parts of the world during the first month to 6 weeks after milking cows are turned on to luscious spring pasture:, In New Zealand the disease appears particularly around about the months of July to September. The clinical symptoms of the disorder are hyperirritability, nervous spasms, etc., which may reach a climax of violent convulsions and death. The blood serum is abnormally low in magnesium and sometimes low in calcium, The point about the disease which is of interest to my subject is its definite association, both in New Zealand and in other parts of the world, with consumption of grass that complies with our present-day chemical standards for pastures.

As a second example Hogget Mortality may be given, This is apparently connected with the consumption of grass, the autumn growth of which is of an unusually luscious nature due to a warm rainy season. With such a pasture as sole food many hundreds of hoggets may die on one farm in a very short space of time

Another disease that might have been unexpected from examination of pasture is the anaemia called in New Zealand "bushsickness" and by other names in the several other different parts of the world in which it occurs.

One may refer also to Bloat - the rapid gaseous distention of the rumen in cows, usually occurring after consumption of the late spring or early summer growth of clovers.

A final example concerns the fertility of bulls grazing on the rich pastures that are characteristic of some of New Zealand's dairying land. Particularly in the Waikato and Taranaki districts it has been shown by the work of Blake and Webster, Veterinarians of the Department of Agriculture, that a considerable proportion of the failure to get cows in calf in these districts may be ascribed to infertility of the bull,, They have made examinations of the semen of bulls and have been able to correlate abnormal morphology of, sperms with known failure to breed. At Wallaceville, Hopkirk and myself have been working for some time on the influence of feeding rations containing high proportions of proteins on male fertility in rats. We have found that essentially similar sperm abnormalities and failure to breed results in rats whose dietary protein is increased above 35%. . . Our results have led us to the conclusion that sterility of bulls in rich dairying districts'may be in part due to the consumption of pasture of abnormally high protein content, Such pastures may contain the astonishingly high proportion of 30 - 35% crude protein and it is usually the practice of the farmer to do his bull as well as possible by keeping him in his beat paddock.

In all of the cases mentioned the pastures would appear on first acquaintance to be well capable of providing adequate nutriment but experience with grazing animals has revealed the unsuspected abnormalities referred to.

All of our knowledge of nutritive requirements of animals and suitability of foods from the aspect of their chemical composition is the product of experience with animal experiments. By making use of this mass of experience we are able. more and more to dispense with the co-operation of the animal,. yet these examples will perhaps illustrate the present limitations of chemical examination and will show that the animal experiment is the only reliable and final criterion of nutritive value.

What then are the measurements that may be made on the animal? First there is capacity of the foodstuffs to maintain the species - to permit it to grow, to live in health and to reproduce itself. This measurement is the most general one and includes all factors that together make up nutritive value. Secondly one may measure production. This, of course, varies with the species, milk from cows, wool from sheep and live weight gains in the cases of beef cattle., lambs and pigs. The most suitable foodstuff will be different for each purpose since the composi-tion and nature of the product varies and since such a high pitch has been reached in the development of strains of animals with specialised production capacities. Thirdly, one may measure the capacity of the food to supply known necessary ingredients of a complete diet such as the carbohydrates, fats, proteins, minerals and vitamins. Measurements of this latter type, except for those on vitamins, can best be made by carrying out what are known as metabolism experiments, that is, by taking accurate records for a period of a week or two of the amount of the constituent ingested by the animal and the amount rejected by way offaeces and urine. The difference between the intake of any one constituent in the food say, for 'example, protein and the amount excreted in the faeces is termed the digestibility and represents the extent to which the alimentary system of the animal may act on and absorb that constituent from the particular food. In practice some qualification of this statement is necessary since, in addition to excreting the non-digested portions of its food, the animal excretes also the waste products of endogenous metabolism. This source of error does not seriously affect the value of the results obtained for the organic constituents.

By determining the excretion in both faeces and urine and comparing this with the amounts ingested an accurate estimate of the gain or loss to the animal of a particular constituent may be arrived at. An experiment conducted along these lines is termed a "balance" experiment, and balance experiments may be applied to measurements of energy and to gaseous products as well as to the solid visible materials such as proteins, minerals, etc. Other measurements on the animal include those on the strength of the bones produced by various rations or the quality of the fat laid down by such rations - the list may be extended almost indefinitely since food is the raw material for all the reactions which go on in the body.

Fur-ther, the animal may be employed in other experiments which yield data indirectly associated with assessment of nutritive value. For instance palatability, of foodstuffs is revealed only by observations on animals and persistency of growth of grasses may be measured by noting the recovery of pastures after they are subjected t 3 grazing.

From what has just been said it;-is obvious that there is no dearth of methods for employing the animal in measurement of nutritive value. Yet specific data concerning pastures are somewhat difficult to find, It is the experience of centuries that natural pastures have maintained herbivorous species, It is also experience that cultivated grasses have maintained domesticated animals. Exceptions occur and some have already been mentioned. Two others may be added, namely, the bone deformities that were observed in South Africa where the herbage is deficient in phosphorous, and the failure of animals tc ?row to expected size in the Falkland Islands where the herbage is deficient in calcium. The recognition of such abnormalities is the result of comparison between the development of animais in a particular area and the sum total of experience in maintaining similar animals elsewhere through long periods of time.

When this method of assessment of the nutritive value is applied to the pastures of New Zealand it would appear that the general level is reasonably high, for here herbivorous species have thriven and the production level, notably in the case of the butterfat of the cow, has reached a high average value.

Such comparisons, however, although they give instructive generalisations, do not yield any specific details. For these application must be made of some of the other methods referred to. For example, take the measurement of production of the various domestic animals on pasture. Pig rearing experiments have been widely recorded and ap-pear to indicate that pasture alone is not a suitable food. For instance, in Germany two sows farrowed on Italian rye-grass only, lost about 100 pounds weight in a short time and the young pigs were small and emaciated, Growth trials with pigs show, however, that clover mixed with' other foods may successfully supply a large part of the protein requirement.

. Direct and accurate comparison of beef and mutton production in stall fed and grazing animals is surrounded by many difficulties. To mention only two there is first in grazing animals the practical impossibility of measuring the composition and amount of dry matter intake and second the greater heat loss and energy consumption in moving round in search of food. Experiment s have, however, been made in America in which two comparable groups of steers were grazed - one group being fed a supplement of maize meal and cot tonseed meal in addition to the grazing Chile the other group was allowed only pasture, Records were kept of live weight gains and of various physical measurements such as percentage fat in a selected rib sample, the proportion of bone in the same sample, tenderness of cooked meat and palatability. In general, results favoured supplement fed cattle. The gains in weight were greater, the amount of fat and bone at a more desirable level, the flesh was slightly more tender and the financial returns were greater. The pasture, however, was a poor one since 4 acres had to be allowed to each steer.

The capacity of pasture to sustain milk production is illustrated by figures quoted from Swedish observations. Milk yields of 45-55 pounds per day over a period of 150 days and one case of a yield of 70 pounds per day for 56 days were obtained from cows receiving pasture as their sole food.

The next method for investigation of nutritive value is the measurement of digestibility, i.e., measurement of the amount of the foodstuff that is absorbed by the animal f'rom its alimentary tract. It is obvious that information of this nature is fundamental to assessment of nutritive value for it, is only the digestible portion that can make any contribution to the nutrition of the body. The technique involved is to be discussed by Dr. Franklin so I shall not go into that aspect. The inf ormation that may be gained from such experiments includes the digestibility not only of the total dry matter of the ingested food but also of the different constituents such as protein and fibre. It has been found that young grass is highly digestible, sheep being able to utilise about 80 per cent of the dry matter. Even the fibre may be utilised approximately to this extent. Age of the plant exerts a profound influence on digestibility and in some hays the percentage digestibility may be 50 or less. In general, the older the plant the smaller is its digestibility. Such information has an important bearing on pasture management and indicates particularly wherein lies the value of the intensive system of rotational grazing.

This method of examination has shown that young pasture is as valuable a food for ruminants as some of the Well known concentrates such as cottonseed meal.

Digestibility experiments which have been made with the horse show that this animal utilises only about 54 per cent of the dry matter of pasture. 70 per cent of the protein is digested but only 33% of the fibre. The caecum of the horse is therefore not as efficient a Converter of fibre as is the rumen of the sheep.

An interesting extension of digestibility experiments with sheep and cattle has been made to grass that has been cut and dried artificially. Rapid drying does not affect digestibility of the various constituents. It appears, therefore, that the nutritional value of young pasture is not an essential function of its fresh green state, apart, of course, from any influence of palatability.

The digestibility experiments on sheep that have just been referred to were carried out by Voodman at Cambridge. The work was run in conjunction with measurements of weight of pasture grown on areas cut at different intervals. The yield of a pasture is of course an important factor affecting its value as a foodstuff and the method of mowing and weighing the produce from areas subjected to different systems of management gives valuable information concerning the different systems. However, the animal can be employed to obtain similar data but in terms of grazing time provided and live weight increase of animals.

An experiment at Aberystwyth will illustrate the method employed. Three series of 5 plots were each grazed by 5 lambs. The lambs were moved from plot to plot at different intervals of time so that the plots of the first series had one month's rest between grazing, those of the second series a fortnight's rest and those of the third series 4 days rest. The object of the experiment was to compare the carrying capacity of the pastures under the three different managements. The gain in weight of the lambs and the grazing days provided per acre were recorded. Grazing days varied since the number of lambs was not sufficient always to denude the plots and, it was necessary to turn in sheep called followers to clear up the excess food as quickly as possible after the experimental lambs had been moved. The grazing provided for the followers was included in the total grazing days. It was found that the greatest live weight increases occurred on the plots with one month's *rest* being 180 pounds per acre compared with 130 pounds per acre from the 4 day rest plots. The grazing day results were in the same sense being approximately 1500 days per acre for the 1st series and 1200 days per acre for the 3rd series. , The monthly period of rotation was therefore shown to be the most desirable. The results from this type of experiment agree substantially with those obtained by Woodman and by others from mowing and weighing trials.

We may turn now to consider the method of employing the animal in comparisons of palatability. It is obvious that if animals have decided preferences, then they will exercise these in selecting their food from a mixed herbage. If there is sufficient of the most palatable plant to satisfy the needs of the grazing stock that plant only might be consumed. Palatability would therefore be a deciding issue in the composition of the food eaten and presumably also should be considered in selecting seed mixtur-es.

Observations have been made by several workers notably by the late Dr. L. Cockayne in New Zealand and also by others at Aberystwyth. Dr. Cockayne stocked an area heavily with sheep and by periodical observations at short intervals noted the order in which'the different species were eaten and the extent to which they were cleared out. A wide range of species was under observation and, of all, meadow grass and cocksfoot were found to be the most palatable while white clover was practically not eaten. The unpalatability of white clover was unsuspected but all of Dr. Cockayne's experiments placed this species low in the estimation of his stock.

In Aberyatwyth two methods are employed for palatability trials. The first is similar to Cockayne's technique, i.e., observation of selection by sheep from a mixed pasture and the second is the preference shown by sheep when allowed to graze freely over continuous plots of pure species. The second method is carried out as follows:- a number of sheep are turned out on to the plots and closely watched. At short intervals of time the number grazing on each plot is noted. Over a large number of observations the average relative number of sheep on each plot is taken to represent the palatability of the particular plot.

The general results show that nutritive value, as we generally reckon it, is not the deciding influence on palatability. Of any two species the more accessible grass is selected first, when palatability is equal, while harshness or hairiness of leaves are secondary fastors lowering palatability.

In the Aberystwyth experiments, clovers were always the most palatable in contrast to Cockayne's results, but were closely followed by cocksfoot and perennial ryegrass while fescues were always unpalatable. Aseasonal variation existed with some species ryegrass, for example, being least palable in summer. The seasonal influence depended on the stage of growth :of the plant, a leafy growth being palatable while stems' were not.

Observations on horses made at Breslau again show that of the grasses perennial ryegrass and cocksfoot are selected first.

An adaptation of grazing trials 'is made to measure persistency of growth of different strains and species. Such a quality is of course intimately linked up with nutritive value, for if a pedigree grass i's to maintain its value it must be able to withstand the continuous attack of the grazing animal under pasture conditions.

Persistency is frequently measured by cutting the pasture or the grass at frequent intervals'but it is nevertheless true that to employ the animal gives a better picture of the process going' on in normal grazing. To embody this "biotic" factor a technique for tethering sheep on plots and allowing them to graze has been developed by Stapledon. The rate of moving the sheep along the plots can be varied to obtain different intensities of grazing. Examination of botanical composition and dry matter production of the pasture at intervals gives the necessary data fo.r assessing the persistency of the different species.

So far only the large domesticated animals have been considered; - there remains now only a brief mention of the use of a small animal, the rat, in measuring vitamin content 'of pastures. It will suffice to indicate that the rat may be employed to measure vitamins without describing the elaborate technique involved.

It has been s tated frequently that domestic animals will always receive adequate supplies of viitamins in their natural foods. This is probably'correct in most cases but certain conditions of vitamin starvation may arise, e.g. in pig keeping.

Last autumn in this country there.: was a fairly widespread incidence of paralysis in young pigs and the particular' type of paralysis was similar to that produced by Vitamin. A deficiency, The diet of the pigs was skim milk and pasture, but the pasture was dried up as a result of the rainless season. Experiments at Wallaceville show that skim milk contains no Vitamin A and it is almost certain that the vitamin is absent from dried up pasture, The hypothesis of' Vitamin A deficiency, then, seems reasonable. The demonstration further, that fresh green pasture is a very rich source of Vitamin A would explain the absence of paralysis in pigs on, a skim milk and pasture ration in normal seasons?

The 'occurrence of Vitamin D in pasture might also. be mentioned since this vitamin is of great importance to the building of firm normal bones. Vegetable materials do not usually contain appreciable amounts of Vitamin D except while they are actually growing in sunlight, If the plant is cut and kept away from sunlight the vitamin seems to be destroyed. The' animal grazing on pasture would therefore ingest a certain amount more vitamin D in its food than the animal fed cut or stored green food. Exposure to the ultra violet rays of sunlight, of course, results in the formation of Vitamin D in the skin but it would seem likely that a heavy coat such as the sheep carries would absorb most of the ultra violet rays. The work just mentioned would show where and how the sheep's supply of Vitamin D is obtained.

This completes what I am afraid is, of necessity, a somewhat sketchy outline of methods in use' for the measurement, by means of the animal itself, of the nutritive value of pasture.

On first consideration it may appear almost unnecessary thus to distinguish amongst the grasses those which are more or less palatable, more or less digestible, 'and so on; some may even remark that pasture supported the domestic animals for centuries before such distinctions were thought of!

Yet with all the advances of civilisation the domestic animal still remains our sole medium for transforming the, to us, unavailable products of the soil to forms available for human food. And with increase in the non agricultural population it becomes increasingly important that this transformation shall be accomplished with the maximum of efficiency* Hence the need for measurement and improvement of the nutritive value of the pasture.
