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VARIATIONS IN THE DIGESTIBLE ENERGY CONTENT OF NEW ZEALAND SHEEP PASTURES

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THE GRAZING OF SHEEP AND BEEF CATTLE on extensive pasture land is an essentially inefficient process, but fortunately it is likely to remain quite the most attractive, easiest, and indeed the only practicable way of utilizing a large proportion of the occupied land of the world.

It is inefficient for the same reasons that make it cheap and attractive—because the stock themselves do most of the work. In some cases they may help to clear or to consolidate the ground, to control weed growth, and in part to fertilize the pasture. The animals select, harvest and process the raw material, and at the same time store and transport the final products.

By the way in which they graze, they can profoundly modify the entire pasture, and, conversely, by modifying the sort of pasture given them to harvest, it is possible in large measure to determine the amount of energy they expend in utilizing it, the nature of the products, and the length of time occupied by the growth or the fattening processes.

Yet, despite its tremendous importance, particularly to New Zealand and Australia, too little is known about pasture as a raw material—and the growing of pasture is, after all, not an end in itself but just the means to a greater end. Pasture is perhaps the most variable raw material fed into any productive machinery, yet a fleece of wool is expected to be grown evenly over the whole year, young stock are expected to maintain a high and even rate of growth, at slaughter a carcass is expected with fat of the correct depth, colour, and distribution, and, after the work the animals have been compelled to do, the meat is expected to be tender and tasty!

Nutritive Value of Pasture

CLASSICAL APPROACH

The characterization of pasture herbage and the measurement of its nutritive value, even in the broadest terms, falls well

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behind, compared with other animal feeding stuffs. This is, of course, largely because the art and science of stock feeding grew in the northern countries of Europe and America where the climate imposes a long period of indoor hand feeding and economy compels the farmer to make the very best use of the various protein and carbohydrate materials he can grow or buy. The rations used may vary quite considerably in composition between store, growing, fattening, pregnant or lactating animals. A knowledge of the quantitative and qualitative nutritional requirements of grazing animals has not yet been developed to a comparable degree—but this must be done.

Most animal or pasture research workers are familiar with the classical systems of feed analysis and evaluation, and with the underlying physiological processes and concepts which they express or interpret. The Starch Equivalent system remains a standard, based as it is on the sound principle of describing feeds as equivalent to the weight of starch, a simple energy source, which was found to produce the same energy storage in fattening animals. From the Starch Equivalent and digestibility of the feed stuffs used, it was possible to derive standard coefficients for the various constituents, digestible crude fibre, protein, ether extract and nitrogen-free extractives and thus in general to allot to any feed an objectively determined value, based on its chemical analysis and digestibility.

Modern Needs

Despite the substantial advances that have been made in the study of ruminant metabolism, there is still no adequate alternative to applying to, for example, the proteins and soluble carbohydrates of grass and clover pastures, the coefficients originally determined for the chemically and biologically different proteins and carbohydrates of linseed cakes, of grains and grain meals, of oat chaff or of fish meal.

Because of this unsatisfactory state of affairs, there is probably little point in attempting to calculate a Starch Equivalent value for lush pasture, and indeed much of the most up-to-date field intake work is based upon the simple use of digestible dry matter or digestible organic matter as a unit of measurement. Theoretically, however, it might be supposed that the nutritive value of the digestible material of pasture would vary, perhaps quite considerably, with maturity of the plants, with changes in botanical composition, or with the function for which the animal was using the feed. The recent work of Raymond has demonstrated that the digestibility, and of Baxter that the net energy value, of a feed may vary according to the level of intake of that feed.

For these and other reasons, it is necessary to be prepared, and indeed be eager, to effect a synthesis of the old with the new, in animal nutrition.

Already there is a lag, for, before this *existing* field of nutrition and husbandry in the established laboratories of the temperate grasslands has really been tackled, there are already clearly in view the tremendous fields of the subtropical, the tropical and the arid grassland areas of the world. As a former New Zealander, I am most anxious to see a rigorous and satisfactory answer to existing problems on high-production temperate pastures; but as a very New Australian—writing, in fact, in Queensland—I am very conscious of, and am indeed rather humbled by, the necessity to scrap many of the concepts and scales of value built up in easier climates so as to admit the fresh ideas and attitudes which will be needed for the different grass and legume species with their different patterns of growth and maturing, their different trends in composition and feeding value, and the new management and utilization techniques which these other, newer grasslands will involve.

Fortunately the means are readily available for at least some of the work which must be done: although little is known of the detailed composition of the proteins of pasture and of the thermodynamics of the rumen, the simple caloric value of feed and the factors which influence it can be readily determined.

Experimental Study of Caloric Value of Pastures

At Ruakura an experiment has been conducted involving the continuous indoor feeding of a number of sheep maintained at predetermined levels of live-weight and thus at different levels of feed intake. Since the sheep were all kept at constant live-weight, they may be assumed to be using energy for a fairly constant set of functions and at a fairly efficient level which might be expected to yield accurate and uncomplicated records of energy digestion.

Continuously after December 1955, and sporadically before this date, in each feeding period of 14 days, three sheep were kept under normal digestion trial conditions and representative samples of feed, residues and faeces voided were obtained; limited chemical data are available for a number of feeding periods spread over the first year of the experiment from July, 1955, to July, 1956, and covering a range of typical sheep pastures from pure ryegrass in early spring through to dominant clover pasture in summer and back to mainly grass again in the winter of 1956.

Methods Used

Paddocks were alternately mown and grazed to avoid any trend away from a true sheep pasture through repeated mowing. Grass cut was similar to that currently being grazed by outside flocks, and was fed twice daily in the amounts necessary to maintain the prescribed live-weight.

The samples obtained were dried off at 105° in the usual way, and after milling were burnt in a B.T.L. high pressure bomb calorimeter using 30 atmospheres of oxygen. Approximately 1 to 1.5 g. of sample was used, which gave a temperature rise of 2 to 3°C. in the reaction vessel (total water equivalent about 2,300g.).

It was necessary to compress the samples into a pellet to ensure that none was blown out of the crucible and failed to burn.

No allowance has been attempted for the caloric loss which may occur in the course of the usual 105° oven-drying process of feed and of faeces samples, nor has a correction been made for the temperature difference between the moisture in the grass eaten and that in the faeces voided.

The standard deviation of single determinations of caloric content, apart from these unknown factors, is about 1 to 2 per cent.

Results

The writer's main interest is in the relationship between pasture intake and productive performance of grazing sheep. The real questions were therefore roughly as follows:

(1) Since the arguments and criticisms in the introductory parts of this paper were largely based on opinion and surmise, just how great are these supposed variations in caloric value of pasture at the stage normally considered sheep feed?

(2) To what may the variations, if any, be attributed?

(3) What likelihood is there that the total, or the digestible, energy content of the herbage actually selected by grazing sheep can be estimated?

Only the data necessary for these basic points will be discussed. A full analysis of all data from the entire experimental period will later be published elsewhere.

Rather surprisingly, and despite a range from pure ryegrass about 1 in. to 2 in. high in early spring to quite a poor stalky grass and clover pasture in early February, the total energy content was practically constant over the year. Even the fully mature rye, fog and clover sward used for the hay had the same caloric content as the short and lush pastures—about 4,470 cal./g. was the average value.

Whatever the change from high protein/low fibre to low protein/high fibre, may involve in the chemical constituents of leaf or stem, the changes clearly involve no great caloric changes.

Digestible energy content was computed thus: Total calories eaten, less total calories excreted divided by total feed eaten.

This criterion, the most useful theoretically as a measure of nutritive value, shows quite definite trends over the season. The highest values found were in early spring, though the sample cut late in May was again approaching the earlier levels. The lowest value found on the fresh pastures was 2,810 cal./g. on fairly mature, rather clover-dominant pasture in February. The "best" pasture from this viewpoint, the rather sappy spring growth, was about 40 per cent. higher in nutritive value than the better-looking mature clover of mid-summer, and was a full 100 per cent. better than the hay.

From the data shown in Figs. 1 and 2, it is evident that a close relationship must be shown between digestible energy content and dry matter digestion coefficient. This is clearly shown in Fig. 3. In other words, the digestibility of the total energy of the pasture was quite similar to that of the dry matter of the pasture.

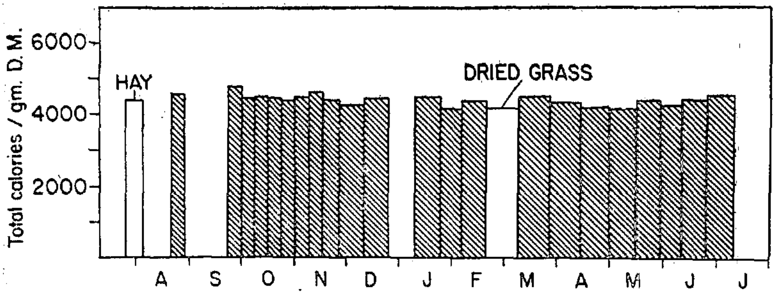

Fig. 1: Gross energy content of pasture.

In general, as this implies, the caloric value of the faeces was similar to or rather higher than that of the pasture from which the faeces was derived, but the actual values varied from one case where the faeces (mean of 3 sheep) was 100 cal./g. lower than the pasture in December, to a case in which the faeces was nearly 500 cal./g. higher, in late February.

The close agreement between digestible energy content and digestibility promises the possibility of a useful prediction equation for digestible energy based upon an index of digestibility, such as faecal nitrogen, introduced by Lancaster, or faecal chromogens, as discussed by Kennedy (see p.56). An empirical regression line of this type will make possible the direct estimation of digestible caloric intake of grazing sheep and the apparently good "fit" of the hay sample into the pasture plots suggests that such a regression may hold for roughages of low digestibility as well as for highly digestible pastures.

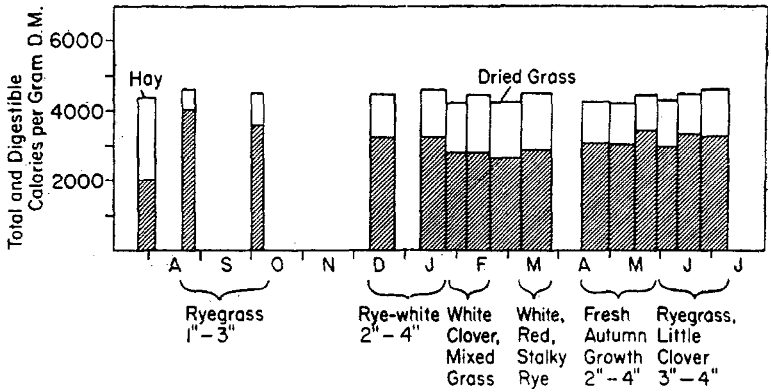

Fig. 2: Digestible energy content of pasture.

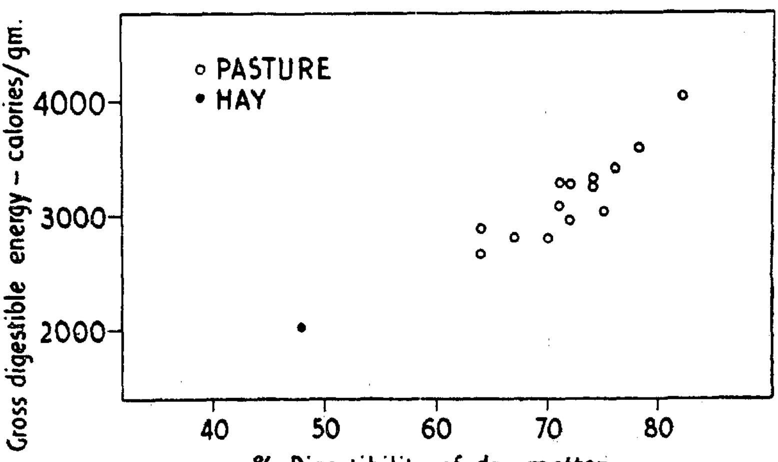

Fig. 3: Relationship between gross digestible energy and digestibility.

One or two other points deserve a passing reference.

There is no evidence so far that either the digestibility of dry matter or the digestible energy content varied between the sheep on the three levels of feed intake. However, although the actual levels of *intake* were in the ratio of about 1 : 1½ : 2, the sheep were all at maintenance, and therefore should be considered as being physiologically at the same level of *nutrition*.

There was very little difference in the caloric content of the faeces of different sheep at the same level of intake, though more data must be studied to make this certain.

Summary and Conclusion

Reverting for a moment to the questions originally set out as being of most direct interest in the preliminary analysis of this data:

(1) How much does the total energy of pastures vary? It has been seen that the total caloric content of different feeds varied surprisingly little, and thus that determinations of caloric value done on the feeds would be of no use as measures of nutritive value. *Digestible* energy, on the other hand, varied quite widely, even within the comparatively small number of pastures studied, which were all cut at a fairly short stage of growth.

(2) To what factors could these variations, if any, be attributed? These variations were associated almost entirely with variations in dry matter digestibility.

(3) What is the likelihood of a direct estimation of the digestible caloric intake of sheep at pasture? Because of the rather close connection between energy and dry matter digestibility it is probable that an accepted index of digestibility (nitrogen or chromogen) can be used to predict caloric value of the feed of individual grazing animals from the composition of the faeces.

Conversely, since on these figures the mean value of the D.D.M. from pasture was about 4,350 cal./g. (range 4,000 to 4,600) such a factor could be used to convert intake in D.D.M. into digestible calories.

DISCUSSION

Dr. C. P. McMeekan: : I would like to make one comment on this paper. Surely it is high time that nutritional workers agreed on some common standard for comparing the nutritive value of pasture. Workers at Grasslands use S.E. many in the U.S.A., T.D.N.; Wallace of Ruakura is using D.O.M. He was criticized for this at the recent International Grasslands Congress. Lambourne now presents his data in terms of digestible energy. Should we not get together and decide upon a uniform system so that work in different centres is comparable.

V. J. Williams: : Since there is a direct correlation between digestible energy and digestible organic matter, I can see no valid reason for going to the extra trouble involved in determining D. E. It is much simpler to determine D.O.M.

Dr. W. K. Kennedy: : I agree with both these comments, so long as we are dealing with pasture forage. However, it is difficult to use a common standard when dealing with foods containing a considerable amount of fats.