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Recent Developments in the Field Study of Sheep Nutrition

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INTRODUCTION

AT the 1950 Conference of this Society several papers were presented by Ruakura workers which reported their experiments in the measurement of feed intake of grazing dairy cows (1). The methods used involved administration of a marker, chromic oxide, twice daily at milking times and the concurrent sampling of the faeces. They were able to show that when these faeces samples were bulked in equal dry weights over fourteen days the concentration of chromic oxide determined by analysis of the bulked sample for each animal gave an estimate of total faeces voided in the period, within plus-minus 5% of the figure found by bag collection of faeces.

By using the relationship between faeces nitrogen percentage and feed digestibility first recognised by Lancaster of Ruakura, they were able to estimate the "intake factor" or "feed-to-faeces" ratio for that particular feed. Combining these two estimates, that of faeces voided and intake factor, they showed that it was possible to estimate the digestible organic matter intake of individual dairy cows within plus-minus 10% for an individual cow-period, and showed that the aggregate of such estimates corresponded quite well for much of the season with figures based upon clipping the grass grown under frames in the pastures being grazed by the cows.

Subsequent seasons' work have fully confirmed the reliability of this method and Dr. Wallace has obtained sufficient data to assess for the first time, the nutrient requirements of free-grazing dairy cows for body maintenance, for live-weight gain and for milk production (2).

Considerable time has since been devoted to testing the reliability of the same or some similar methods for free-grazing sheep, because many outstanding questions in sheep nutrition await the development of objective methods of estimating the quantity and quality of the feed eaten.

In this paper I propose to outline to you the steps by which we have proceeded, to show you the nature of the difficulties involved and the accuracy of the method we have finally selected for use in the field. I want then to discuss the field trials we are conducting this present season and to consider what inferences we may draw from them concerning the efficiency, and thus the costs, of our production of fat lambs.

DEVELOPMENT OF TECHNIQUES

1. Faeces Estimation:

In order to plan a method which would entail least frequent handling of our animals we studied first the rate of passage of individual doses of marker, for it appeared likely that this information was the key to rapid progress.

We found that the rate and pattern of excretion shown in Figure 1 was consistently obtained in trials with wethers ranging from two-tooth to four years old, on a wide range of pastures and at several periods of the year.

Marker Concentration as a function of time since dosing

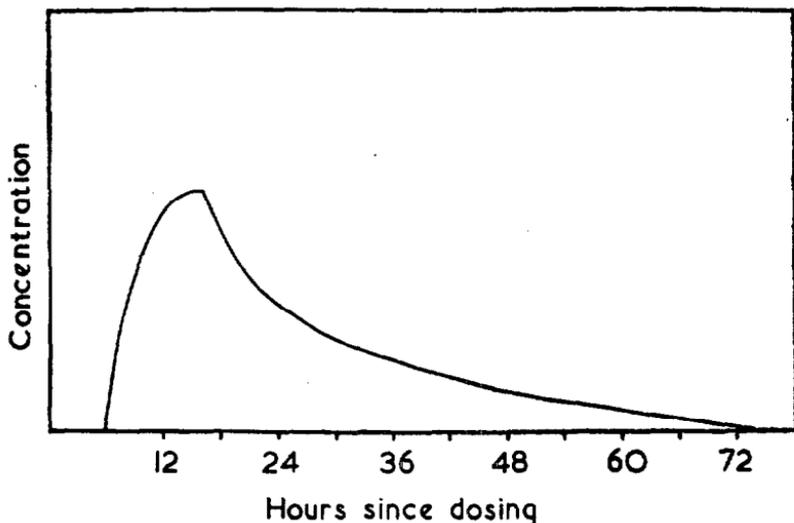


FIG 1: Pattern of excretion of a single dose of marker.

The rate was slower, and both the time of first appearance and the time of peak concentrations were later by 3–6 hours on poor pastures, and later by 12–18 hours on hay, while for a given feed type, the rate was slightly faster the higher the level of feed intake.

The main features of the marker/time curve were, however, reproduced on all normal sheep pastures, and we were encouraged then to apply this preliminary knowledge to our main task.

We desired a time-schedule of dosing which would establish a steady concentration of marker in the faeces and which would enable us, by taking faeces samples at the same times, to determine the mean value of this marker concentration. The known total dosage of marker in a given period, divided by its concentration in the bulked samples, would then serve as an estimate of the weight of faeces voided in this period.

We quickly realised that the basic mode of excretion was so sharp that there was little likelihood of our deriving any worthwhile estimate from only one dose per day, while correspondingly no worthwhile use could be made of a technique which necessitated handling sheep more than twice per day.

Marker/time curve - 12 hour intervals.

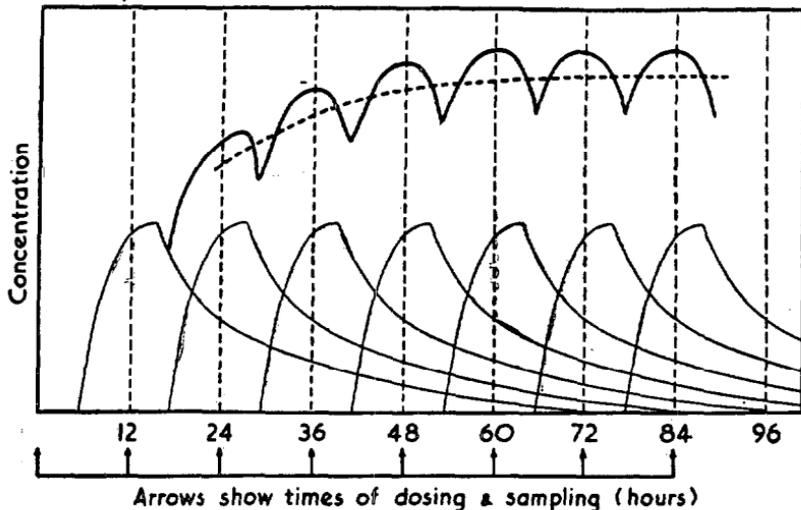


FIG. 2: Effect of dosing every 12 hours.

Figure 2 shows the form of the fluctuating marker envelope which was predicted when the basic marker/time curves were superimposed at 12 hour intervals.

It seemed likely that such a dosing routine would establish a "stable" concentration within 3-4 days but that samples of faeces taken at the dosing times would contain too high a concentration of marker and would thus give a biased estimate of the faeces production.

Marker/time curve - 9 & 15 hour intervals

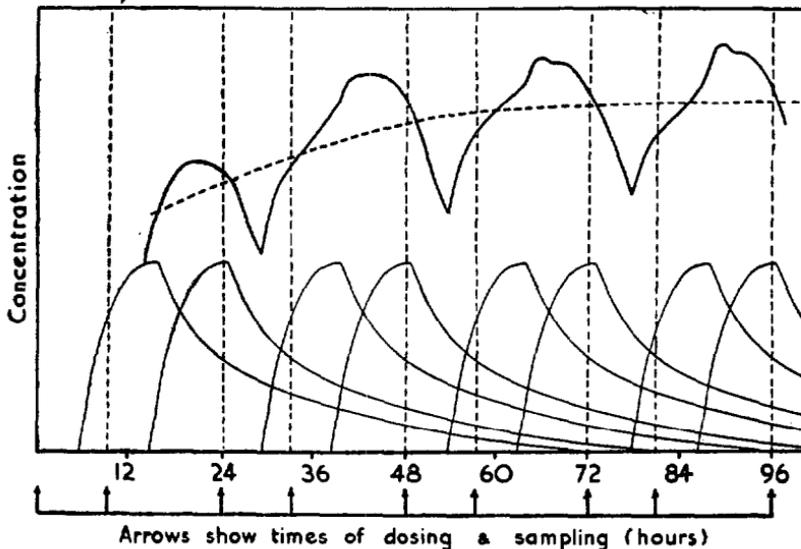


FIG. 3: Effect of dosing at uneven intervals.

Figure 3 shows the corresponding marker "envelope" predicted for a routine in which doses were given, and samples taken, at intervals of 9 and 15 hours alternately. It appeared that in this case our samples should far better represent both the high and the low periods of marker concentration and should yield a fairly unbiased estimate of its mean value.

It is, of course, evident that this was an idealised approach and could do no more than serve as a general guide. The accuracy of the method was then tested in two indoor feeding experiments in which marker was administered twice daily at 8 a.m. and 5 p.m. over periods of 14 days—4 days preperiod and 10 days bulking period.

In the first experiment eight sheep were fed at two different levels with young spring grass and the estimates of faeces output obtained by bulking morning and evening "grab samples," to use the colloquial term, over ten days, ranged from 95 to 103% of the actual figure as found by concurrent collection of the faeces.

In the second trial six sheep were fed indoors on more mature grass and the individual estimates over 10 days ranged from 85 to 105% of the actual figure.

In a third trial with three wethers equipped with faeces bags and grazing on high quality early summer pasture the estimates from grab samples bulked over a 14-day period following a 3-day preperiod were 94, 98 and 102% of the figure obtained by bag collection.

The overall average estimate for these seventeen sheep—periods was 97 plus-minus 6% of the true figure—an accuracy which compared favourably with the corresponding data for cows and which was

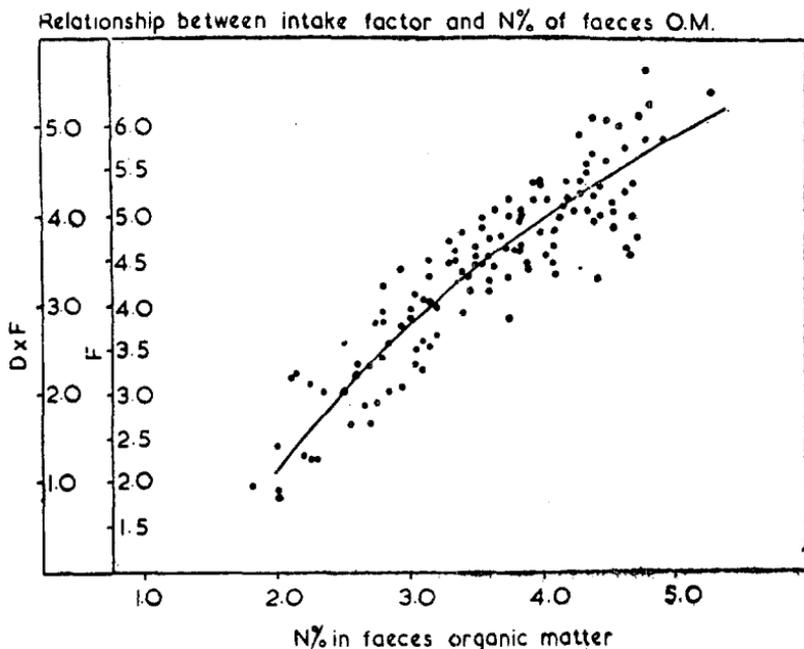


FIG. 4: Method of estimating "intake factor" F , and $D \times F$ for direct calculation of D.O.M. intake.

somewhat superior to the estimate involved in the second stage of this indirect method, the estimation of the feed/faeces ratio or intake factor.

2. Intake Factor.

Several methods have been proposed by which the digestibility of a feed may be determined from chemical analysis of faeces derived from it. Thus either the lignin, the nitrogen, or the acetone-soluble plant-pigment content of faeces may provide data for an empirical relationship of useful accuracy. For a variety of reasons we have so far used the percentage of nitrogen in the faeces organic matter as the best all-round index, and combined data taken from the literature and from several series of digestibility trials at Ruakura are shown in Figure 4, where each point represents the mean intake factor for a group of 2-4 sheep plotted as a function of the true mean nitrogen percentage of the group over the trial period.

We have excluded from the graph the results of digestibility trials conducted with sheep but using feeds other than typical sheep pastures, although this degree of selection did not materially alter the relationship shown above.

From this graph we conclude that the mean intake factor may be estimated with an error in the vicinity of plus-minus 10% from the mean nitrogen percentage in the faeces.

In practice, of course, we do not know this true mean nitrogen percentage since the only sample available for analysis in a field measurement is one composed of equal weights of morning and evening grab samples over the measurement period. Information from analyses of samples from over 300 sheep-days suggests that the mean of morning and evening grab samples is close to that of a completely representative sample and that the error incurred in this way probably does not exceed a further plus-minus 3%.

3. Overall Estimate of Feed Intake

In the two experiments mentioned earlier with a total of fourteen stall fed sheep we were able to compare actual feed intakes with those estimated by combined use of chromic oxide and nitrogen.

In the first trial the ratios of estimated to actual intake of D.O.M. ranged from 97 to 118% for individual sheep, and in the second trial from 88 to 111%. The mean value for all fourteen sheep-periods was 103 plus-minus 10%, but in view of the small numbers involved I prefer to work on the assumption of an error up to plus-minus 15%.

This then, has summarised the position for those interested in the technique side of sheep nutrition studies. The method of choice is thus essentially the same as that used at Ruakura for dairy cows, though it is probable that the estimates obtained for sheep are a little less accurate than those for cattle.

FIELD APPLICATIONS

Having presented the foregoing experimental results in some considerable detail, it will, I think, suffice if I mention rather briefly some of the snares and pitfalls that await the field experimenter and which have seemed of sufficient importance to warrant some temporary modification of method.

A sheep rather dislikes being dosed and grab sampled every morning and night for extended periods, which is a perfectly understandable reaction. They very soon learn to associate their regular trip to a pen with the procedure that follows it, and it may become quite impossible to obtain samples from some sheep, however slowly or however rapidly they are brought into the pen.

We have, therefore, this year tried out a modified method in which we dosed only every second week which largely avoided this conditioning process, though it must certainly have increased the error of the estimate of intake beyond the percentage suggested earlier.

We knew that the length of the dosing preperiod could be reduced by giving preliminary large doses of marker to, as it were saturate, the stomach contents following this initial "boost" with regular dosing twice per day for a further 4-6 days, over the latter three to five days of which faeces samples might be taken and bulked. The effect of this routine is shown in Figure 5 where the concentration of chromic oxide found in morning and afternoon grab samples is plotted against time.

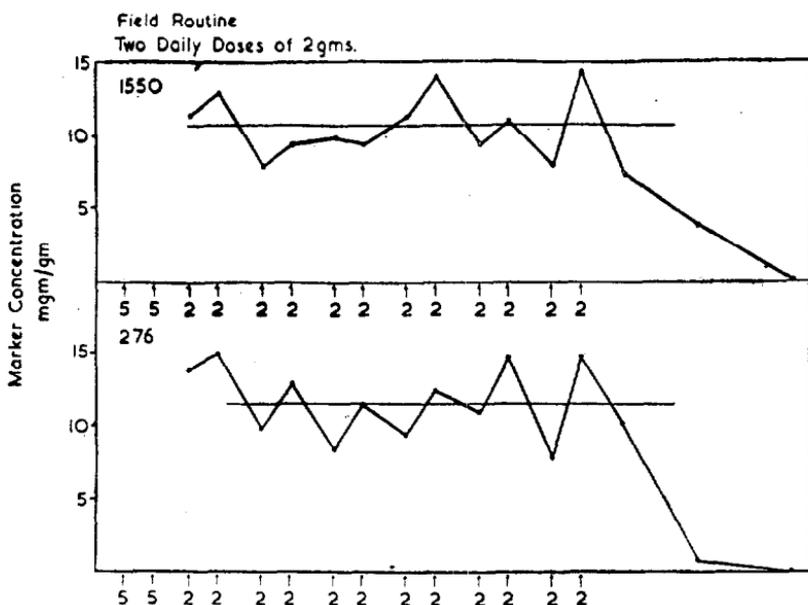


FIG. 5: Two typical sets of results. The first two samples in each case were not used in preparing the bulked sample for analysis.

This is at best only a compromise solution and we must in future attempt a continuous dosing routine, even if this necessitates some culling out of unco-operative animals.

NUTRITION EXPERIMENT, 1954

I want to proceed to an account of our most recent applied experimental work and to discuss its implications in at least their broad outlines.

Design:

We began last winter with two groups of eight five-year-old ewes, each group consisting of two empty and six pregnant sheep, the latter all due to lamb almost simultaneously. From mating time they were all run together under typical store conditions until July. One group was then confined to a paddock of less than one acre where they stayed until weaning in January. This imposed a rather low level of nutrition and these are referred to hereafter as the low-plane ewes. The others were the high-plane group and were provided with good feed ad lib from July onwards.

Measurements made:

The individual feed intake of each sheep was estimated in terms of digestible organic matter (D.O.M.) in each alternate week by the condensed routine outlined above, between August and January. Feed requirements for the store period from January to July were estimated from the considerable amount of data obtained with wethers during the preliminary experiments mentioned at the beginning of this paper. The D.O.M. intake of their lambs was estimated by chromic oxide dosing, just as for the ewes, once the lambs reached a sufficient size. Milk yields of the ewes were determined by the usual "Plunket" method in the alternate weeks in which no intake measurements were made.

General Purpose of the Experiments:

We originally hoped to obtain data over the entire productive season from August to January sufficient to enable us to assess the D.O.M. requirements of sheep for maintenance, for liveweight gain and for lactation, when combined with the existing information for wethers. Quite the best study of the utilisation of nutrients by sheep is that made at Cambridge by Wallace (4) who analysed the results of his stall feeding trials in this way with a wealth of detail, and provided a model for subsequent work.

Presentation of Results:

A proper analysis of the present data would require initial assumptions of a rather far-reaching nature, or else a rather complex statistical analysis for which there has not yet been time.

I shall, therefore, consider only how the total feed consumption of our sheep was distributed between the various phases of the productive cycle—how much of it must be debited as the overhead cost of just maintaining a ewe throughout the year, how much was directly and how much indirectly converted into marketable produce or stored as body reserves. We can see then how the gross and the nett efficiency of lamb production varied and what factors most affected it.

Experimental Results:

I would like first to show two slides to illustrate the general nature of the measurements and their seasonal trends.

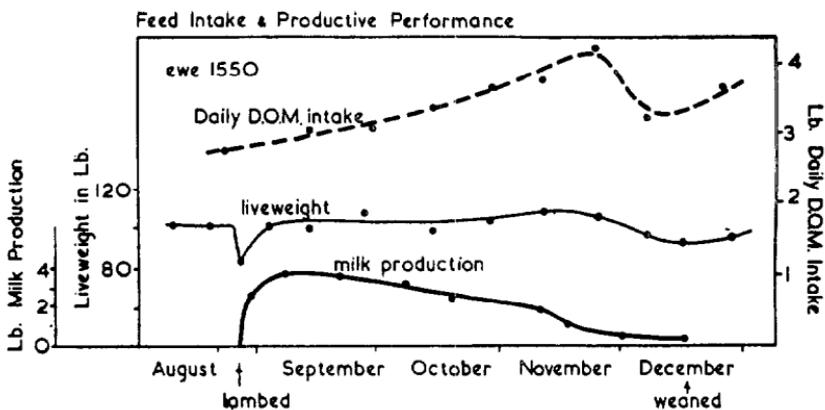


FIG. 6: Season's record of ewe 1550, High plane group.

Figure 6 presents the season's record of the ewe 1550, who featured in an earlier diagram. Her record was selected because it followed closely the mean figures for the high-plane group as a whole, showing a typical lactation curve, small and variable live-weight changes and a steady rise in D.O.M. intake during the spring and early summer. The fall in weight and in feed intake shown in November-December followed a change to a paddock of fresh but evidently unsuitable feed.

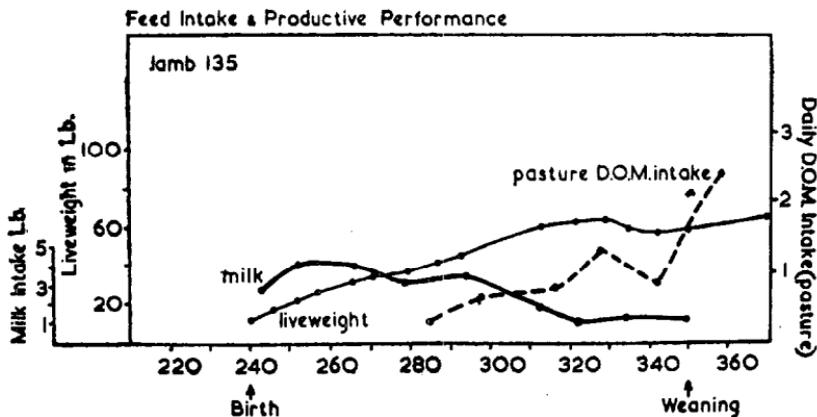


FIG. 7: Season's record of lamb 135, High plane group. The horizontal scale shows the number of days of the year which had elapsed, i.e. December 31st = 365.

Figure 7 shows the growth of lamb 135 and our estimates of his milk and pasture intake. Again this individual was selected because while his records were typical of the group, they showed most clearly the rather interesting response to the change to longer feed in late spring.

It is from such records that the following admittedly tentative analysis has been made.

TABLE 1: Estimated total feed consumption of ewes in the year in relation to their total production.

Class	D.O.M. lb. consumed				Lamb carcass meat	Ewe		Total lb. D.O.M. per lb. meat produced
	By ewe for		Directly by lamb	Total		L. Wgt. gain	Carcass meat	
	Body maintenance	Milk prod. and/or L.Wt. gain						
L.P. dry ewes (2)	630	140	0	770	0	25	12.5	62
L.P. ewes with single lambs (5)	520	140	100	760	30.4	8	4	29
H.P. dry ewes (2)	640	80	0	720	0	32	16	45
H.P. ewes with single lambs (6)	650	130	100	880	32.5	5	2.5	25
L.P. ewe with twins	610	210	200	1020	48	10	5	24

Table 1 compares the total D.O.M. estimated to be consumed by the ewes over the entire year in relation to their total production.

It is interesting to note that the figures for the high-plane ewes and lambs which used 25lb. D.O.M. per lb. total meat, or 27lb. D.O.M. per lb. of lamb, would lead us to an estimate of about 240lb. of lamb per acre from a pasture giving a gross yield under grazing of 6500lb. D.O.M. per acre. From the high figure of 62lb. D.O.M. per lb. meat given by the dry ewes fattening under low-plane conditions it would appear that under a system of overstocking with fattening sheep the meat production could fall to barely 100lb. an acre.

TABLE 2: Comparison of feed costs, showing the importance of the "ewe maintenance."

Class	lb. D.O.M. used per lb. lamb produced		
	For ewe maintenance (overhead)	By ewe + lamb for productive purposes (nett)	Total (gross)
L.P. singles (5)	17.2	7.8	25
L.P. twins (1)	12.5	8.5	21
H.P. singles (6)	20.1	6.9	27

Table 2 shows the gross and the nett cost and their difference, which is the "ewe maintenance overhead," of lamb production, disregarding the weight changes of the ewes. Retention of the data for the one ewe with twins is reasonable in a preliminary study for the birthweight, growth rate and killing weights of her lambs were close to average Ruakura weights for low-plane twins, and her milk production exceeded that of the low-plane single-rearing ewes by about 35%. This ratio is very similar to those generally reported for twin compared with single-rearing ewes.

This ewe and her lambs showed higher nett cost but lower "overhead" cost per pound of lamb produced than the ewes of other classes, which means simply that she and her twins consumed a greater proportion of their total requirements in the spring when grass is plentiful and cheap, and relatively less of their total requirements in the seasons when grass is more valuable.

TABLE 3: The milk production and the feed debited to it, in the four months of lactation (totals for 5 and 6 sheep).

Class		Approx. period of lactation (days)			
		0-30	30-60	60-90	90-120
L.P. singles (5)	Milk lb.	338	266	221	156
	D.O.M. lb.	100	150	183	242
	D.O.M./Milk lb.	0.3	0.6	0.8	1.6
H.P. singles (6)	Milk lb.	580	510	316	174
	D.O.M. lb.	167	169	197	205
	D.O.M./Milk lb.	0.3	0.3	0.6	1.2

Table 3 shows mean milk production and the amounts of D.O.M. debited against it, for successive periods of approximately 30 days covering the whole lactation.

The increasing amount of feed consumed per pound of milk secreted indicates clearly the uneconomic nature of prolonged lactation, particularly when it is realised that the amount of D.O.M. used thus for milk production in the fourth month was substantially greater than the amount eaten by the lambs themselves in this period.

Over the whole four months roughly twice as much feed was eaten by the ewes for milk production as was eaten directly by the lambs, except for our solitary twinner whose lambs ate almost as much as she did.

Our high-plane ewes seem to have milked at a lower nett and a slightly lower gross cost than the low-plane ewes, and within each group, as over the whole number, the better yielders were the more efficient nett producers. The high yielders were also the heaviest sheep, as is generally the case, with therefore a greater "overhead" maintenance requirement throughout the year. Even when this extra allowance was added as a charge against milk produced the higher yielders were still the more efficient. In other words the increased cost of maintaining the bigger ewes was more than offset by their greater milk production.

With that I shall have to leave the matter. Until we are able to check the assumptions which were necessary even for this sketchy treatment it would be most unwise to look for and discuss any finer points of difference.

Conclusion:

Ruakura has introduced many improvements into orthodox fat-lamb farming in the last few years—improvements which emphasise the importance of high lambing percentages, the importance of really economical use of the valuable feed on hand in autumn, the importance of ample feeding during the first part of lactation and of early weaning of lambs while the pasture is still plentiful and good. These are all vital and inter-related steps towards low-cost fat-lamb production, and we hope that this new technique in field nutrition studies may help us to amplify and perhaps extend these management methods, to our common good.

We know of course that the technique is cumbersome and scarcely accurate enough, but we are working to modify and to improve it. Imperfect though it is, it remains the only way yet devised for the detailed study of the nutrition of grazing animals and we hope that its use may make possible quite accurate assessments of the quantitative feed requirements of sheep and of beef cattle for body maintenance, for liveweight gain and for milk production, and perhaps add to our scant knowledge of the relationship between feed quality and the partition of its nutrients among these various functions.

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- (1) Wallace, L. R. (1950): Proc. N.Z. Soc. Anim. Prod. 10 : 41.
- (2) Annual Report N.Z. Department Agriculture 1951.
- (3) Raymond, W. F. (1954): J. Brit. Grassland Soc.
- (4) Wallace, L. R. (1948): J. Agric. Sci. 38 : 367.

Discussion

Mr. SMITH: What allowance did you make for maintenance requirement of ewes of different live weight?

Mr. LAMBOURNE: I assumed the requirements of different ewes to be proportional to their live weights, with an extra allowance during lactation for "working maintenance."

Mr. SMITH: Did you take into account the differences in caloric value of the live weight changes made?

Mr. LAMBOURNE: No. I agree with your implication that crude live weight is an unsatisfactory measure. I hope this year to find whether live weight gains are true gains of muscle, or fat, or merely stomach contents.

Prof. CAMPBELL: Could the apparent decline in lactation efficiency be due to increased energy spent in grazing, and how did you allow for this?

Mr. LAMBOURNE: My data suggests that a ewe uses at least 30-50% more D.O.M. when lactating than at the same body weight when dry, in the variety of ways generally grouped as maintenance. This includes the energy cost of grazing which may become large. However it also includes losses during fermentation and digestion, and the energy needed for metabolic respiratory and repair work and for temperature control. My allowance for what Wallace called the increased "working maintenance" was to increase the basic D.O.M. requirement for any live weight by some 40%. After this correction there still remained a progressive increase in the D.O.M. which had to be charged directly against milk production.

Mr. LANCASTER: The error of the estimate of feed intake shown by your figures was lower than we have found for dairy cows. I would like to see that confirmed by other experiments. Have you any evidence for the accuracy of the method used this year in which you dosed only in alternate weeks?

Mr. LAMBOURNE: My figure of 103 + 10% was drawn from only fourteen animals, and I commented at the time that I thought it rather optimistic and preferred + 15% as a working figure. I have no corresponding data for our simplified routine but I think it less accurate.