
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

MAINTENANCE AND LACTATION REQUIREMENTS OF GRAZING SHEEP

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SUMMARY

Experiments have been conducted with penned sheep and grazing sheep fed at maintenance. In comparison with pen-fed sheep, grazing of long pasture for a short time increased maintenance requirements by about 20 to 30%, but grazing of short pasture which just enabled sheep to maintain body weight caused a 50 to 80% increase. Shearing caused further increases of the order of 20 to 40% for the first month after shearing in autumn. Attempts have been made to measure the intake of lactating ewes. Estimates, subject to considerable error, placed the requirements about 20% above those of existing feeding standards.

THIS PAPER summarizes the work undertaken at Lincoln College in connection with the feed requirements of grazing sheep, and of the factors which affect them. Coop (1961) and Coop and Hill (1962) presented evidence that the energy requirements for maintenance of grazing sheep were some 50 to 80% higher than for sheep fed in pens. It was suggested that the increased energy cost of grazing was primarily due to the energy cost of harvesting the grass, a cost which could vary greatly with the length and density of pasture available. Lambourne (1961) described experiments from which he deduced that very large increases in the estimated maintenance energy requirements of grazing sheep could be ascribed to a stress condition in sheep on sparse grazing. Lambourne also showed that this energy cost could be greatly reduced if, instead of grazing short pasture sufficient only for their maintenance needs, the sheep were confined in pens and allowed out on to long grass for short periods of grazing.

With dairy cows Wallace (1961) and later Hutton (1962) have proposed increased maintenance requirements for grazing dairy cattle, but this is contested by U.K. research workers.

In both the dairy cow and sheep work referred to above the estimation of intake by the grazing animal has been by the chromic oxide/faecal nitrogen method. Estimates of the energy requirements of grazing animals must therefore be dependent on the accuracy and reliability of this indirect method, which, although it has certain limitations, is the most practicable technique available at present. Nevertheless, confirmation of some of the results obtained by an independent method would be most acceptable.

Recently, Graham (1962) used respiratory exchange methods for measuring energy cost of grazing turfs of five widely differing types of pasture. Hand feeding the cut pasture did not increase energy output but grazing of the turfs did increase it by an amount equivalent to 12 to 18% of hand-feeding to a maintenance level.

The work reported in the present paper falls into two categories:

(1) Those experiments concerned with studying factors affecting maintenance requirements, and

(2) Those concerned with estimating the feed intake of lactating ewes.

FACTORS AFFECTING MAINTENANCE REQUIREMENTS OF SHEEP

Materials and Methods

Two experiments were conducted in 1961 and 1962 during the autumn and early winter period from March to June.

Experiment A

In 1961 40 mature Romney ewes of mean liveweight 123 lb were randomized into the following five treatments:

(1) *Short grass-Long time.* 10 ewes were provided continuous grazing on short pasture sufficient to maintain liveweight constant.

(2) *Long grass-Short time.* Ten ewes were enclosed on gratings and allowed access to long pasture for two periods each of approximately ¾ hour per day during which time they ate sufficient to maintain liveweight constant.

(3) *Long grass-Long time.* Eight ewes were provided continuous grazing on long grass and made rapid liveweight gains.

(4) *Penned Sheep-Indoors.* Six ewes were penned inside a shed and fed freshly cut herbage, lucerne and turnips to maintain liveweight constant.

(5) *Penned sheep-Outdoors.* Six ewes were penned in the open paddock adjacent to Groups 1 to 3 and fed on the same feeds as Group 4 to maintain constant liveweight.

The experiments lasted for 13 weeks.

The intake of the three grazing groups was estimated by the chromic oxide/faecal nitrogen technique as described in previous papers (Coop and Hill, 1962). The dosing and sampling routine employed was shown to give reliable results in all three groups. Digestibility trials were used to determine the digestible organic matter (D.O.M.) intakes of the sheep in Groups 4 and 5.

Four ewes of each group of grazing sheep were shorn at the start of the trial and thereafter at monthly intervals to keep them in a "shorn" condition, simulating the first month after a normal shearing. The other ewes were unshorn, but all had been given the normal summer shearing in early December, 1960.

The purpose behind the shearing was not so much to measure the effect of shearing *per se* but rather to increase artificially the energy or heat requirement of these sheep. If, in fact, grazing sheep require 50 to 80% more feed for maintenance than pen-fed animals, then some of this additional energy must appear as heat which would make the grazing animals more cold tolerant than would otherwise be the case. If it could be shown that the shorn sheep in the continuous grazing high maintenance group (Group 1) suffered less from the cold than the shorn sheep in the low maintenance groups (Groups 2, 4 and 5), it would confirm without the measurement of intake by the chromic oxide/faecal nitrogen technique that maintenance requirement in the continuously grazed group was in fact high. In the event, this simple thought turned out to be more complex than anticipated.

Experiment B

In 1962, 42 mature Romney ewes of mean initial liveweight 129 lb were randomized into the following groups:

(1) *Short grass-Long time.* Ten ewes (5 woolly, 5 shorn).

(2) *Long grass-Short time.* Ten ewes (5 woolly, 5 shorn).

(3) *Long grass-Long time.* Ten ewes (5 woolly, 5 shorn).

(4) *Penned Sheep-Outdoors.* Four woolly ewes fed to maintain liveweight.

(5) *Penned Sheep-Outdoors.* Four shorn ewes fed to maintain liveweight.

(6) *Penned Sheep-Outdoors.* Four shorn ewes fed at 1½ times maintenance level.

The trial lasted for 10 weeks from mid-March to the end of May. Techniques used were the same as in the previous year except that the penned ewes were fed a ration of 3 parts lucerne hay and 1 part concentrates.

Results

The results of the 1961 trial are shown in Table 1.

TABLE 1: SUMMARY OF RESULTS OF 1961 MAINTENANCE TRIAL

Group	*Intake D.O.M./day (lb)*	*Mean Gain 13 weeks (lb)*	MR_{100}
1. Short Grass — Long time			
Woolly	2.03	+0.25	1.78 ±0.05
Shorn	2.17	+0.25	1.85 ±0.05
2. Long Grass — Short time			
Woolly	1.41	—1.7	1.34 ±0.06
Shorn	1.38	—10.0	1.53 ±0.09
3. Long Grass — Long time			
Woolly	2.57	+12.1	1.73 ±0.05
Shorn	3.02	+13.3	1.96 ±0.13
4. Penned Indoors			
Woolly	1.05	—0.4	1.01 ±0.04
5. Penned Outdoors			
Woolly	1.10	—2.7	1.10 ±0.05

NOTE: MR_{100} represents the calculated maintenance requirement of a 100 lb sheep. In converting the measured intakes into maintenance requirement of a 100 lb sheep the following assumptions were made: that the cost of gain or loss in liveweight is 2½ lb D.O.M. per lb in 100 lb sheep increasing to 4 lb in 130 lb sheep and that maintenance requirement varies as the 0.73 power of liveweight.

The results of the 1962 trial are shown in Table 2.

TABLE 2: INTAKE, LIVEWEIGHT GAIN AND ESTIMATED MAINTENANCE REQUIREMENT OF SHEEP IN 1962 TRIAL

Group	*Intake D.O.M./day (lb)*	*Mean Gain 10 weeks (lb)*	MR_{100}
1. Short Grass — Long time			
Woolly	1.78	+1.0	1.52
Shorn	2.53	+4.0	1.97
2. Long Grass — Short time			
Woolly	1.16	—7.4	1.20
Shorn	1.33	—9.4	1.40
3. Long Grass — Long time			
Woolly	2.69	+22	1.39
Shorn	3.50	+20	1.86
4. Penned Outdoors			
Woolly	1.02	—5	1.01
Shorn	1.02	—12	1.40
Shorn	1.46	—2	1.41

In this table the same assumptions have been made in arriving at MR_{100} as stated in Table 1. Regression of intake on gain in the shorn penned sheep gives the equation $I_{122} = 1.58 + 3.11\,g$ indicating a 3 lb D.O.M. requirement for 1 lb gain.

These results may be reduced to the summary given in Table 3 in which MR_{100} (maintenance of a 100 lb sheep) only is considered. It is proposed to give no consideration to Group 3 (the Long grass-Long time group) in which intakes were high, since these results are questionable owing to bias in using the nitrogen regression equation at high intake levels.

TABLE 3: INFLUENCE OF TREATMENT ON MR_{100}

Treatment	*1961* *Woolly*	*Shorn*	*1962* *Woolly*	*Shorn*
Penned indoors	1.01			
Penned outdoors	1.10		1.01	1.40
Long Grass — short time	1.34	1.53	1.20	1.40
Short Grass — long time	1.78	1.85	1.52	1.97

These results show:

(1) Exposure to the elements during the autumn may cause a 10% increase in feed requirements even in woolly sheep (*cf* 1.10 versus 1.01) though this difference is not statistically significant.

(2) A further increase of 20% (*cf* 1.34 v. 1.10 and 1.20 v. 1.01) is brought about by grazing even when the pasture is capable of being harvested with a minimum of energy and time.

(3) An increase over indoor feeding of 50 to 80% is brought about when the pasture is kept lawn-like by a continuous and high grazing pressure and when grazing time exceeds 6 to 8 hours.

(4) Shearing brings about a significant increase in feed requirement of the order of 40% in pen-fed sheep, and 20% in low maintenance grazing sheep. In the high maintenance grazing sheep results were inconsistent, the shearing increase being less than 10% in 1961 but 30% in 1962. These observations add weight to the proposition that the maintenance requirement of grazing sheep is high.

ESTIMATION OF THE FEED REQUIREMENTS FOR MILK PRODUCTION

Determination of grazing intake and feed requirements for lactating animals is subject to more errors than determination of feed requirements for maintenance. Nevertheless, it was considered worth while to attempt this to determine the extent of the differences between the requirements of grazing and pen-fed animals. Three major obstacles were:

(1) The mathematical difficulty of apportioning intake between the needs for liveweight, maintenance, liveweight gain and lactation when all are varying simultaneously.

(2) The physical difficulty and the emotional upset to the sheep of yarding and handling ewes and lambs twice daily for chromic oxide dosing and faecal sampling.

(3) The probable presence of errors in the application of faecal nitrogen /digestibility regression equations at the high levels of intake experienced.

Materials and Methods

To minimize the work of handling the sheep, chromic oxide impregnated paper was used in preference to chromic oxide capsules and once-daily dosing and sampling was practised. This paper, developed by Corbett *et al.* (1960) at the Rowett Research Institute, varied in chromic oxide content more than had been expected. However, it did reduce the diurnal variation in chromic oxide excretion to the extent that the variation with once-daily dosing of paper was approximately the same as for twice-daily dosing with capsules. Unfortunately, the once-daily sampling introduced a bias of 7% and all faecal outputs had to be corrected arbitrarily by this amount.

Digestibility of pasture decreases with increasing level of intake. This has been noted by Minson and Raymond (1958), Hutton (1962) and in the Lincoln College tests. The use of a nitrogen regression equation to predict digestibility or indigestibility when that equation has been developed at maintenance intakes will probably overestimate intake if applied to levels above maintenance. At the levels used in these lactation trials, and in the long grass-long time groups reported earlier, the degree of overestimation is probably 10% and may even be 15%. Intakes calculated for these groups from the original nitrogen regression equation were, therefore, arbitrarily decreased by 10%.

In the spring of 1960, 12 Romney and 12 first-cross Border Leicester × Romney four-tooth ewes were used. Half of each group was rearing singles and the other half twin lambs. Both groups were run on small plots of good rye-grass-white clover pasture near the sheepyards. At the commencement of the trial, the lambs were 7 to 10 days old and the trial continued for 12 weeks. Intakes and liveweight gains of ewes and lambs were measured. Milk production of the ewes was estimated by the technique of weighing the lambs before and after suckling.

In the following spring, 1961, 16 Romney ewes were similarly employed, divided into 2 groups of 8 ewes, one half of each group rearing singles, and the other half, twins. One group (high plane) was run at 4 ewes per acre so that feed was not limiting and the ewes gained in weight. Another group (medium plane) was run at 6 ewes per acre so that they maintained their weight constant. At the start of the trial, which lasted for 10 weeks, the lambs were 10 to 14 days old.

To take account of the application of the nitrogen regression equation all estimated intakes have been *reduced* by 10%.

RESULTS

Table 4 summarizes the observations made.

TABLE 4: MEAN DAILY INTAKE, GAIN AND MILK PRODUCTION (LB) OF EWES IN 1960 AND 1961 LACTATION TRIALS

Year	*1960*				*1961*			
Breed	*Romney*		*Border × Romney*		*Romney*		*Romney*	
Feeding Level	*High Plane*		*High Plane*		*High Plane*		*Medium Plane*	
No. of lambs	*Single*	*Twins*	*Single*	*Twins*	*Single*	*Twins*	*Single*	*Twins*
No. of ewes	6	6	6	6	4	4	4	4
Mean L.W.	130	120	138	128	132	130	111	113
Intake (D.O.M.)	3.05	3.30	3.71	4.14	4.71	4.51	2.94	4.05
Ewe gain	+0.31	+0.11	+0.24	+0.18	+0.14	+0.12	—0.06	+0.01
Milk production	2.30	3.33	3.41	4.00	3.92	3.63	2.57	3.59
Lamb gain	0.54	0.43	0.64	0.49	0.73	0.51	0.48	0.43

Multiple regression analysis of intake on production from all ewes in each year gives the following equations:

1960 $I_{\mathrm{DOM}} = 0.025\ W^{0.73} + 1.9G + 0.70M$ .... [1]

1961 $I_{\mathrm{DOM}} = 0.061\ W^{0.73} + 2.6G + 0.53M$ .... [2]

where I_{DOM} is the daily intake of D.O.M. in lb, W is the mean liveweight in lb, and G and M are mean daily weight gain (lb) and milk production (lb) per ewe respectively.

There are wide differences between these two equations and the experimental observations are obviously much too inaccurate for the regression coefficients to be meaningful. Thus in Equation 1 estimates of maintenance requirements obtained are lower even than for pen-fed dry sheep. This accounts for the apparent increase in the lactational requirements. In Equation 2 the situation is reversed. Another difficulty is that, if digestibility decreases as intake increases, and unless a sliding scale of digestibility with intake is used, then it follows that the equation must underestimate maintenance and overestimate lactation requirements.

An alternative and not altogether satisfactory approach to the problem of assessing lactational requirements is to assume:

(1) That maintenance needs of the lactating sheep are of the same order as for sheep on long grass-short time type of grazing.
(2) That maintenance needs vary as $W^{0.73}$.
(3) That an intake of the order of 2½ lb D.O.M. is required per lb weight gain.

The feed not accounted for is then allocated to lactation. This gives values of 0.48 and 0.67 lb D.O.M. per lb milk in 1960 and 1961 respectively. Whatever device is used to extract the lactational from the total requirement gives estimates which vary from approximately 0.5 to 0.7 lb D.O.M. per lb milk as the mean for the measured 10- or 12-week lactation.

To bring the data to a more practical level, the important thing is the overall intake rather than its allocation into requirements for maintenance, gain and lactation. From Table 4 the following typical situation may be deduced:

(1) A 120 lb Romney ewe rearing a single lamb to 65 lb at 100 days of age will produce about 2½ lb milk per day, consume a mean of a little over 3.0 lb D.O.M. per day itself and gain 10 to 15 lb in the 10- to 12-week period.
(2) The same ewe rearing twins to 50 to 55 lb each, at 100 days, will produce 3½ lb milk per day, and consume 3½ to 4 lb D.O.M. per day with little liveweight change to itself.

DISCUSSION

Comparison with existing feeding standards may now be made. For the lactation requirement the U.S. National

Research Council (N.R.C.) (1956) gives no separate figure but the U.K. Ministry of Agriculture (*Rations for Livestock*, 1960) gives 0.4 lb S.E. equivalent to 0.45 lb D.O.M. per lb milk. Wallace's (1948) work at Cambridge, using penned ewes, gave the equivalent of 0.50 lb D.O.M. per lb milk. The figure for grazing ewes given in this paper is, therefore, between 0 and 40% above these figures.

If one calculates the overall requirement for maintenance and lactation of a 120 lb ewe producing, for example, 2½ lb milk per day, the figures from the N.R.C., Ministry of Agriculture and Wallace are, respectively, 2.6, 2.7 and 2.5 lb D.O.M. per day. The figure for grazing sheep given here is 3.0 lb D.O.M. per day, which is 15 to 20% higher. For the ewe producing 3½ lb milk per day the figure for grazing sheep is 20% above the standards.

Clearly, sufficient confidence cannot be placed in any of these figures to make any strong claims about them. In the N.R.C. and Ministry of Agriculture figures, the maintenance component is undoubtedly too high and the figures presented here for the lactation requirements of grazing sheep are not above suspicion on account of the technique used. But taking them as they stand, an increase of the order of 20% would not be inconsistent with the magnitude of the energy cost observed earlier for grazing sheep where the pasture is long and dense and easily harvested. What may also be significant is that this increase is much less than the extraordinarily large increase observed in the short grass maintenance.

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DISCUSSION

Q: *Do the equations in this paper go through the origin, and are the regression coefficients significant?*

PROFESSOR I. E. COOP: If liveweight, gain and milk production are all zero, then the equations predict zero intake. If one assumes that gain is zero then for a given liveweight, regression of intake on milk production will give maintenance for that liveweight. The range of milk production obtained in both sheep and cattle makes the extrapolation to zero milk production fairly large, causing considerable error in estimated maintenance.

There has been insufficient time to test the significance of the various regression coefficients.

Q: *Would Professor Coop please give fuller details of the procedure adopted to estimate milk production in the ewes?*

PROFESSOR COOP: Milk production was measured by removing the lambs, allowing them to suckle at intervals and weighing the lambs before and after suckling. This was done for one 24-hour period each week, the intervals being 6 times per 24 hours at the beginning of lactation, decreasing to 4 times per 24 hours at the end.

DR L. R. WALLACE: *Since ewe milk production was measured by the increase in liveweight of lambs before and after suckling, the large variations known to occur in energy content per unit volume of ewe milk would form another variable. Was it possible to correct for this in any way?*

PROFESSOR COOP: No milk samples were taken. I want to acknowledge the errors involved in the milk requirement study. Apart from the intake technique used, the errors in measuring milk production of ewes are considerably greater than those in dairy cattle owing to the method and frequency of milking. Also our study lasted for some 10 to 12 weeks as compared with 8 to 9 months in the Ruakura trials with dairy cows.

Q: *Wool growth is a productive function utilizing energy. Was any allowance made for the energy component of the wool?*

PROFESSOR COOP: Our figures for maintenance include the energy requirement for wool growth. Since wool growth is irreversible and wool cannot yield energy back to the animal, allowance must be made for it in maintenance. It has not been made clear whether or not overseas figures contain this allowance, and I would think from the way they were measured that no allowance has been made. To this extent our figures would be higher than overseas figures.

DR A. H. CARTER: Possible criticism of the results should be levelled at the basic equation and its assumptions, not at the statistical method. If the model were in fact appropriate, the derived estimates are the "best" in some reasonable sense. But the validity of the model may be seriously questioned. In particular, inclusion of a constant term (or other variables) may be necessary if intake as measured is not in fact completely determined by the three variables actually used.