

Growth and Wool Production of Merino Hoggets Related to Grazing Intake in a South Australian Environment

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Summary

The growth of young sheep grazing mature summer pasture South Australia is severely retarded. The risk of mortality, and the current loss of wool production represents a serious economic problem.

At Roseworthy an attempt has been made to define the problem in quantitative terms by relating growth and productive changes to seasonal differences in grazing intake. This paper presents a progress report of this work. Techniques used for assessing energy and nitrogen intake are outlined.

The general picture emerges that severe nutritional stresses occur in the summer and autumn. These arise from the growing animal's inability to derive satisfactory amounts of both energy and protein from the mature pasture.

INTRODUCTION

Retarded growth of young sheep in summer and autumn is a common problem in the winter-rainfall areas of southern Australia. In special areas or circumstances factors such as internal parasites (Banks 1956), copper and/or cobalt deficiencies (Lee 1951), and avitaminosis A (Pierce 1945, 1946, 1947) may be involved. However in a broad sense it is considered that the problem is related to the inability of mature summer pastures in this environment to supply sufficient amounts of energy and protein for growth and production. At Kybybolite, Allden and Anderson (1957) have reported the corrective effects of various supplementary feeding regimes upon summer growth in hoggets. At Roseworthy an attempt is being made to measure growth and wool production rates in young sheep and relate these to seasonal changes in their nutrient intake from pasture.

EXPERIMENTAL

(i) **Environment.**—Roseworthy College is situated on what may be described as "better class mallee country". Mean annual rainfall is 17 in. of which the greater part falls in winter and early spring. Pastures are composed of annual species including wimmera rye grass (*Lolium rigidum*), barley grass (*Hordeum leporinum*), and brome grasses (*Bromus spp.*); burr medic (*Medicago denticulata*), and barrel medic (*Medicago tribuloides*); and weeds, notably soursob (*Oxalis pescaprae*), and prickly jack (*Emex australis*).

Pastures have a short growing period from the average opening rains in May until October. This terminates in a rapid maturation. If in sufficient bulk, the mature pasture "stands-over" in the summer-autumn dry period.

Rainfall and temperature data for the period of observations are indicated in Figure 3. Above average rainfall was recorded in 1956 (21.53 in.), pasture growth was abundant, and a considerable amount of dry pasture was available for the summer-autumn period. The opening rains of 1957 were uncertain and the yearly total well below average (9.07 in.).

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(ii) **Data.**—(1) Sheep: The experimental flock consisted of 24 single Merino lambs from a common sire. However in this report, only the results of growth and wool production (Figure 3) of the 14 wethers of this flock from which faecal collections were made are included. Two deaths occurred during the period of observations. These were in April-May 1957, when the sheep were in a very weak condition. One death was attributed to a dog attack, and the other to a suspected clostridial infection.

(2) Schedule: The experimental plan is summarised in Figure 1. This experiment was conducted on "average pasture", set stocked for the greater period of the observations at a rate which

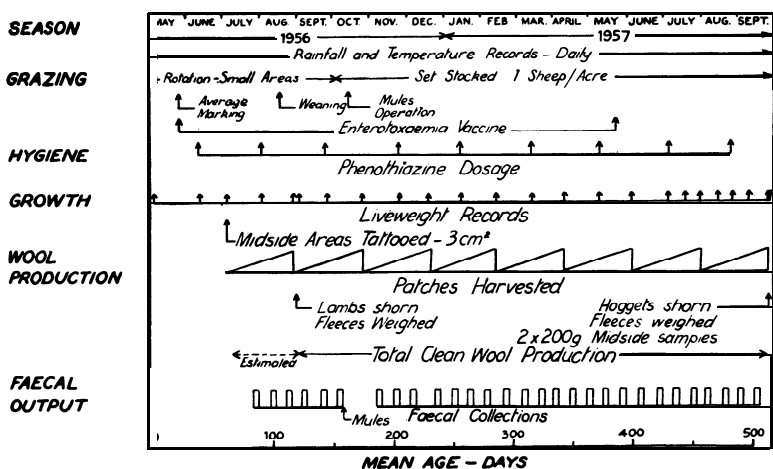


FIG. 1—Experimental plan and observations.

appeared to offer an adequate **quantity** of feed at all times. Under these conditions productivity would largely be controlled by seasonal changes in **quality** and appetite for the feed available.

(3) **Techniques:** Total clean wool production between shearings was calculated for each sheep from **greasy** weight and the mean yield of opposite midside samples. Production for 56 day periods was estimated by dividing this total by proportionate tattooed patch production. Clean wool weights from the small patch samples were obtained after ether and distilled water extractions.

The 14 wethers in the flock were harnessed and bagged for faecal collections for 4 successive days at two weekly intervals as indicated in Figure 1. Thus faecal collections were made on 16 days within the 56 day production periods excepting periods 2 and 3 when mean faecal outputs were based on 12 days. Short term collections were adopted to minimise the restrictive effect of the collection equipment on grazing activity (Hutchinson 1956). Twenty per cent. aliquots of the daily collections were dried at 50°C for 24 hours and bulked. Mean, moisture free, faecal weights were determined for each 4 day collection from each sheep.

A semi-microKjeldahl procedure, with selenium as catalyst, was used for nitrogen analysis. These determinations have been completed for a subgroup of six wethers. The mean growth rate, wool production and faecal output for this subgroup agree closely with the means for the entire wether group.

(iii) **The Estimation of Grazing Intake.**—Observations reported here form part of a broader experimental programme. During its course, seasonal changes in the digestibility of herbage by adult

sheep have been measured. Prediction relationships based upon these metabolism observations have been freely used in this experiment. It is realised that age of sheep, year, and paddock differences are being over-looked. However, between seasonal differences in the regular climatic pattern of this environment would provide by far the greatest source of variation and in each case predictions are based upon a *full* seasonal range of pasture quality.

(1) Dry Matter Intake: Various workers (Gallup and Briggs 1948; Lancaster 1949 a, b; Raymond *et al.* 1954; Hutchinson 1956; Milford 1957) have indicated the possible use of faecal nitrogen relationships for estimating grazing intake. The desirability of developing these relationships locally has been stressed (Hutchinson 1956; Milford 1957). At Roseworthy the following prediction equation has been derived from 26 digestibility observations with pasture. Dry Matter Intake = 147 + 99.5 x (Faecal Nitrogen) (1)

g/day

g/day

An analysis by one of us (K.J.H.) has indicated that dry matter and nitrogen intake are the major factors governing faecal nitrogen loss in sheep. The influence of nitrogen is only apparent at very high and very low levels of total nitrogen intake. Within a wide central range of nitrogen intake, *circa* 8 to 45 g/day, faecal nitrogen is linearly related to dry matter intake with a high correlation coefficient ($r = +0.900$). Most observations reported here appear to lie within this range. The strong influence of dry matter intake seems to arise from a high metabolic content in faecal nitrogen (Blaxter and Mitchell 1948).

TABLE I

*STANDARD ERRORS OF PREDICTED VALUES FOR DRY MATTER INTAKE FOR A RANGE OF FAECAL NITROGEN VALUES

Faecal	Nitrogen	g/day
6	9	12
±80	±91	±109

$$* \text{Obtained as } s \left(1 + \frac{1}{N} + \frac{(x - \bar{x})^2}{\sum x^2} \right)^{\frac{1}{2}}$$

where 's' is the residual standard error after regression.

(2) Nitrogen Intake: The main method being developed at this laboratory depends upon the measurement of aggregate nitrogen transactions. In the static sense the following is true for any nutritional situation :

Intake N = Faecal N + Urine N + Wool N ± Gain or Loss in Body N

(1) (2) (3) (4)
Measurements of (1) (2) and (3) can be made with grazing animals. At Roseworthy ewes are catheterised and the urine is collected in a perspex belly tank. Results are not sufficient for presentation at this stage.

Indications of the capacity of the mature Merino for storing and subsequently catabolising body nitrogen, under the stresses imposed by this environment, suggest the importance of assessing change in body nitrogen (4). The latter may be reflected by measurements of the nitrogen content of the skin (Hutchinson 1957).

An alternative method for estimating nitrogen intake, which has been used in this report, is to apply the appropriate term for apparent nitrogen digestibility (A.N.D. %) to faecal nitrogen loss.

$$\text{Nitrogen Intake} = \text{Faecal Nitrogen} \times \frac{100}{100 - \text{A.N.D.}\%}$$

In this series of observations the last term has not been measured directly by conducting concurrent digestibility trials. However, a useful relationship exists between this term, as y and apparent dry matter digestibility percent (A.D.M.D.%), as x. Figure 2 shows this relationship for the 26 metabolism observations

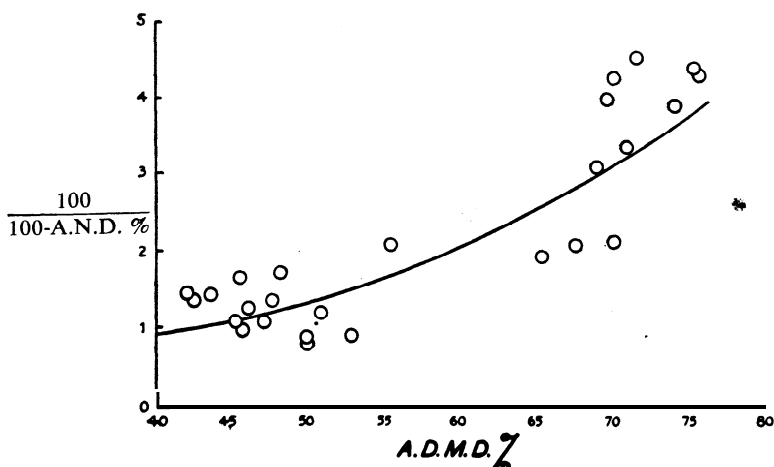


FIG. 2-Digestibility observations for a full seasonal range of cut pasture at Roseworthy. The y-ordinate is the digestibility term which when multiplied by faecal nitrogen gives nitrogen intake as the product. This curve was fitted as $\log y = a + bx$.

made with Roseworthy pasture. A logarithmic curve has been fitted giving the following relationship:

$$\log y = -0.745 + 0.0177 x \dots \dots \dots (2)$$

Using *calculated* values for x obtained from equation (1) a very similar relationship was obtained.—

$$\log y = -0.720 + 0.0171 x \dots \dots \dots (3)$$

The steps taken to assess nitrogen intake are summarised in Table 2. In order to arrive at a figure for total error a combination of equations (1) and (3) has been used.

TABLE II**
Coefficient of Variation of Predicted Values for Nitrogen Intake.

Calculated A.D.M.D. %	40	70
Coefficient of Variation %	36	35

**As a simple ratio the term $\frac{100}{100 - \text{A.N.D.}\%}$ can be rearranged as Nitrogen Intake/Faecal Nitrogen. Hence the logarithmic form of equations (2) and (3) is $\log \text{N Intake} - \log \text{Faecal N} = a + bx$. Because Faecal N was a direct observation and values of x used in (3) were *calculated* from (1), then the total error involved in predicting nitrogen intake, expressed as the coefficient of variation, was obtained by antilogging the standard error from the log data.

The approach is obviously tenuous. Hence it is not surprising that the errors of prediction indicated in Table 2 are large. However, the following features mitigate the disadvantages of the method.

(1) The estimated apparent dry matter digestibilities of herbage eaten for the eight seasonal periods (Table 2) are in good agreement with measured seasonal trends at Roseworthy (unpublished data).

(2) It is expected that the differences in nitrogen intake to be measured are very large.

RESULTS AND DISCUSSION

(i) **Growth Rate.**—Cumulative growth from birth to hogget shearing is shown in Figure 3. Nett change in body-weight for the subgroup is recorded in Table 3. All results have been corrected for the amount of fleece carried.

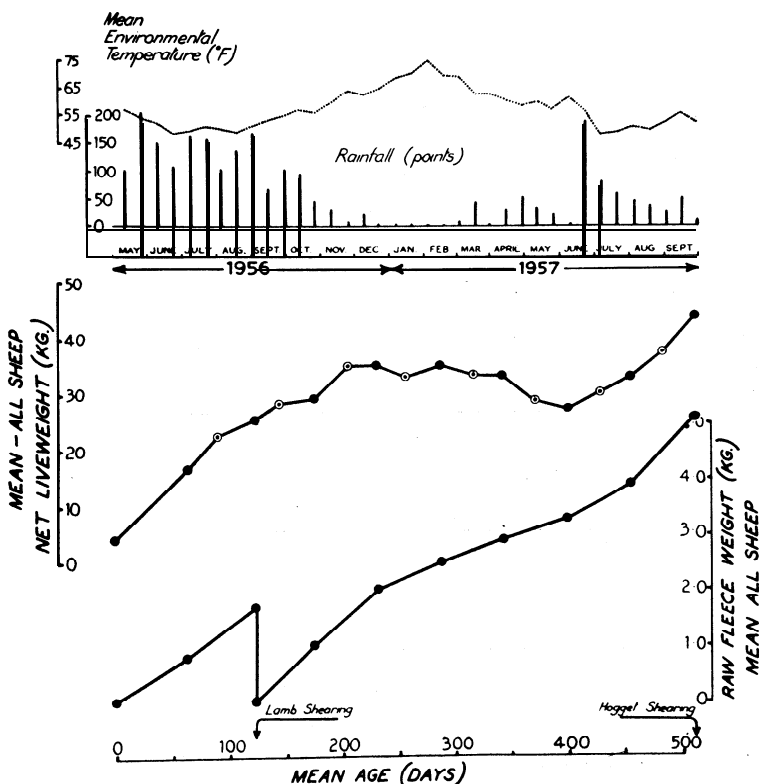


FIG. 3—Showing rainfall and temperature data for the period of observations, together with cumulative production records. End of period observations are indicated as ● and intervening observations as dot in circle.

With a good season for pasture growth it seems possible for the debt in hogget body growth to be overtaken by the end of the spring period. Coop and Clark's (1955) work in New Zealand has indicated that potential adult wool production may not be affected by one such period of nutritional stress. Their results indicate an adverse effect on longevity and fertility. Disadvantages however

TABLE III.

Mean Growth and Wool Production for 56 Day Periods of the Subgroup of Six Wethers together with the Calculations of Mean Nutrient Intakes.

Period	Date	Live-weight change kg/56 days	Clean Wool kg/56 days	Faecal Dry Weight g/day	Faeces Nitrogen %	Calculated Intake as Dry Matter g/day	Estimated Apparent Digestible Dry Matter g/day	Calculated A.D.M.D. %	Calculated* Value for (y-1)	Estimated Apparent Digestible Nitrogen g/day
1	2.vii.1956-27.viii.1956	+ 9.0	0.61	182	3.38	759	577	76	3.0	17
2	27.viii.1956-28.x.1956	+ 3.6	0.69	239	3.27	924	685	74	2.7	20
3	28.x.1956-18.xii.1956	+ 6.4	0.64	376	2.44	1060	685	65	1.5	14
4	18.xii.1956-12.i.1957	— 1.0	0.32	420	1.58	808	388	48	0.3	2
5	12.i.1957-9.iv.1957	— 3.7	0.28	494	1.43	851	357	42	0	0
6	9.iv.1957-4.vi.1957	— 2.1	0.21	356	1.47	668	312	47	0.2	1
7	4.vi.1957-30.vii.1957	+ 3.6	0.44	413	1.89	924	511	55	0.7	5
8	30.vii.1957-26.ix.1957	+ 11.3	0.89	410	3.13	1425	1015	71	2.2	27

* See Text; \bar{y} is calculated from equation (3).

may be considerably increased by successive intervals of under-nutrition. There is also an important short term risk of heavy mortalities in the summer and autumn.

(ii) **Wool Production.**—Cumulative raw fleece production is presented in Figure 3. Changes in clean fleece growth rate for the subgroup are included in Table 3. Production trends are essentially similar to those for body weight.

If the maximum spring rate of wool growth could have been maintained, clean wool production per head would have been increased by approximately 40 per cent.

(iii) **Grazing Intake.**—(1) Dry Matter: Calculations for each period appear in Table 3.

Levels of apparent digestible dry matter intake are included in Table 3. These reflect energy intake at this category. They indicate that grazing provides insufficient energy for growing sheep in the summer-autumn period.

For illustration, results from appropriate periods have been converted to net energy assuming a calorific value of 4.4 kg-cal per g apparent digestible dry matter (Swift *et al.* 1950) and employing a mean conversion efficiency of 53 per cent.* This conversion figure has been calculated from Marston's (1948) calorimetric data for fed Merino sheep and is in reasonable agreement with the factors suggested in Brody's (1945) compilation of calorimetric studies with fed steers.

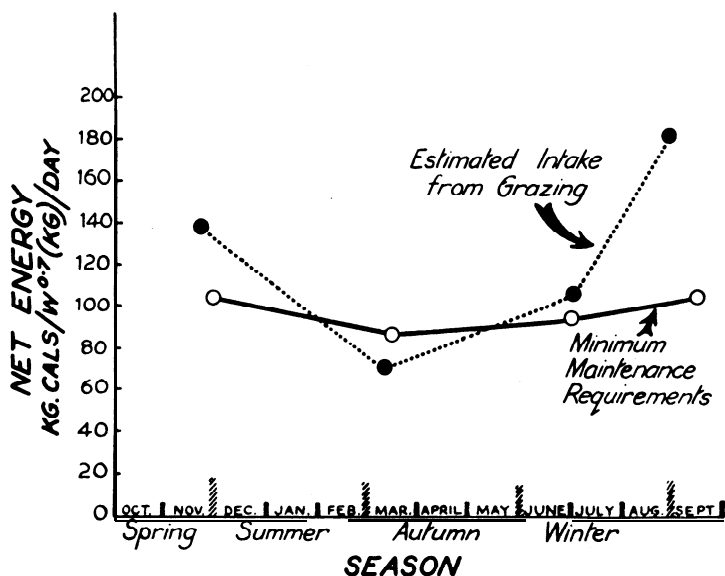


FIG. 4.—Comparison of estimated nett energy intake from grazing (mean 6 wethers) with observed minimum nett energy requirements (Pierce 1934) for maintenance of growing Merino sheep.

These converted data have been compared in Figure 4 with observations on the standard metabolism of Merino lambs (Pierce 1934) grazing Adelaide pastures in the period November 1930 to

*Based on a good quality ration. Hence the energy stress indicated may be under-estimated, since there is a widely held opinion that the efficiency of utilisation of metabolisable energy is lower for poor quality diets (Blaxter 1950).

September 1931. Standard metabolism was measured by Pierce after 48 hours fast, and the extracted data are from animals which were lying during the period of observation. Under these conditions heat production measurements represent *near minimum* maintenance requirements for nett energy which are uncorrected for the field activities of standing, foraging etc.

The inability of pasture to meet even the minimum energy requirements for maintenance in the summer-autumn period is clearly illustrated in Figure 4. Body weight changes recorded in Table 3 suggest the adequacy of the illustration.

(2) Nitrogen Intake: Intakes of apparent digestible nitrogen have been calculated as follows:—

$$\text{A.D.N.} = \text{Faecal Nitrogen} \times (y - 1)$$

where y is the term

$$y = \frac{100}{100 - \text{A.N.D.}\%}$$

Values are presented in Table 3. It can be seen from Figure 2 that the statistical average value for $(y-1)$ approaches zero when the apparent dry matter digestibility falls below 45 per cent. At this point intake of apparent digestible nitrogen must also approach zero i.e. faecal nitrogen loss becomes as high as dietary nitrogen intake.

The 45 per cent. level of apparent dry matter digestibility has been commonly recorded in digestibility trials with mature summer pasture residues. Thus the implications of the fitted curve are as follows:

(1) Grazing animals would appear to be in a frankly negative nitrogen balance in the summer-autumn period.

(2) This situation would change dramatically after satisfactory opening rains which are followed by a rapid rise to perhaps 70 per cent. in the dry matter digestibility of herbage eaten. Correspondingly nitrogen intakes would then be at a luxury level.

(iv) *Production and Nutrient Intake*.—It is evident from the foregoing sections that both energy and protein limit production in summer and autumn. In Figure 5 three-dimensional relationships show the varying nutrient intake levels achieved and their productive outcomes. The following are the main features of this presentation:

(1) levels of protein and energy intake from pasture are highly correlated. Hence in this data it is not possible to interpret the relative importance of energy and protein as factors responsible for hogget ill thrift in this environment.

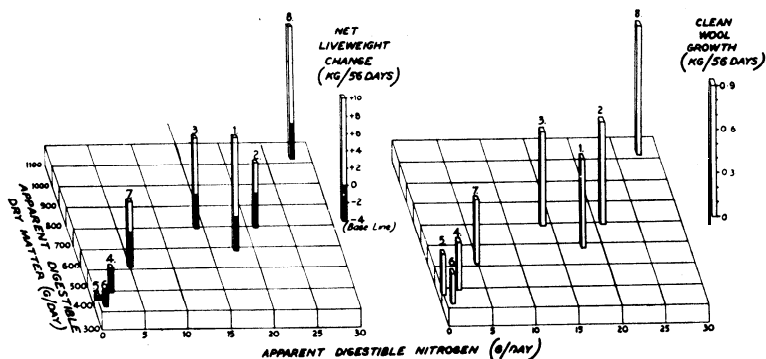


FIG. 5.—Observed rates of production in body growth and clean wool in relation to mean estimates of nutrient intake from grazing (6 wethers). Periods are indicated by numerals.

(2) Production is strongly related to nutrient intake in all possible combinations viz. body weight versus energy intake; body weight **versus** nitrogen intake; wool production **versus** energy intake ; wool production **versus** nitrogen intake. While this does not assist with interpretation because of (1), it does strikingly indicate the fact that the summer-autumn decline is a nutritional problem which can be removed by feeding suitable supplements.

The question of optimum types and levels of supplementation remains to be solved. The close association between energy metabolism and protein synthesis in the animal, indicated in dynamic biochemistry suggests the need for strict experimental control in this phase of the investigations. Given this solution there remains the problem of studying the interaction between any form of supplementation and the normal grazing activity of the animal.

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