ESTIMATES OF THE INTAKE AND DIGESTION OF NITROGEN BY SHEEP GRAZING A MEDITERRANEAN PASTURE AS IT MATURES AND SENESCES

D.K. REVELL[A], *S.K. BAKER*[AB] *and D.B. PURSER*[B]

[A] Faculty of Agriculture, The University of Western Australia (Animal Science), Nedlands, W.A. 6009
[B] CSIRO Division of Animal Production, Private Bag, Wembley, W.A. 6014

SUMMARY

The level of production by sheep that graze a Mediterranean pasture as it matures and senesces depends on diet selection. By estimating diet selection under these conditions using 2 methods, we predict that the intake of nitrogen (N) and amount of N apparently digested (ADN) decreases as the pasture matures and senesces, but that it decreases at a slower rate than the decline in pasture N content and digestibility. A consequence of this diet selection is that wool growth did not decline concurrently with pasture quality. There was a lag between the decline in the predicted amount of ADN and the decline in wool growth; wool growth began to decline about 3 weeks after the onset of senescence.
Keywords: sheep, nitrogen intake, Mediterranean pasture, diet selection, wool growth.

INTRODUCTION

In a Mediterranean environment with annual-type pastures, distinct seasonal variation in the feed supply occurs (Purser 1980). At the end of spring when the pasture matures and senesces, the quality of pasture declines rapidly. For example, the nitrogen (N) content may decrease by 47% within 1 month (Hume and Purser 1975). Under such changing conditions, the precise relationships between pasture quality and animal production are not clear, as measurements of these components have generally been made over intervals of at least 1 month.

During the period of pasture maturation and senescence at the end of spring, the pasture is not homogeneous; it contains mixtures of green and dry material, and legumes and grasses at different stages of maturity. The composition of the diet selected depends on the degree of preference for a particular component of the pasture and the availability of this component (Arnold 1980).

As the quantity of pasture available to grazing sheep at the end of spring is unlikely to limit animal production (Purser 1980), the amount of N digested will be an important determinant of wool growth at this time of year. We have used 2 methods to estimate at weekly intervals the N intake (NI) and the amount of N apparently digested (ADN) by grazing sheep when the pasture matured and senesced and we discuss the relationships between pasture quality, diet selection and wool growth.

MATERIALS AND METHODS

Experimental site, pasture and animals

The experiment was conducted at Yalanbee, the CSIRO Research Station at Bakers Hill, approximately 65 km east of Perth (31°45'S,116°28'E). Prior to pasture senescence the sheep grazed 2 plots, each of 0.5 ha. At the start of the experiment, 1 plot contained over *90% Trifolium subterraneum* cv. Mount Barker while the other contained over *90% T. subterraneum* cv. Dinninup. Volunteer grasses made up the remainder of the swards, and were mainly brome grass and annual ryegrass. The onset of pasture senescence occurred 1 week earlier in the Dinninup plot than the Mount Barker plot and, due to possible differences in the rate of senescence between the 2 plots, the sheep were placed on the Dinninup plot after it began to senesce. As 2 plots were used prior to the onset of senescence, the amount of pasture on offer in the Dinninup plot from the onset of pasture senescence through to the completion of the experiment (3.3 to 2.5 t/ha) was sufficient to pose no limitation to animal production (Dunlop *et al.* 1984).

Pasture samples were collected each week from 5 sites on each plot. Pasture was cut to ground level within a quadrat of 40 x 20 cm. Samples were dried for 24 hours at 80°C and bulked for each plot each week. The proportions of legumes and grasses, and of green and dry pasture were assessed visually at weekly intervals.

Fifteen Merino wethers (2.5 years old and approximately 52 kg) grazed the experimental plots and were part of a separate experiment to determine the effect of either protein or methionine supplements on wool growth (Revel1 1992). Five of the sheep received no supplements and served as the control group. In the experiment reported here, we have used the data from these 5 sheep to estimate NI and ADN. The data from the 10 sheep that received supplements were not used because the provision of the supplements was likely to have affected the amount of N excreted in the faeces (Revel1 1992) and this would have affected the estimations of ADN. The animals grazed the plots from early September until the end of

November 1990. All sheep were weighed weekly between 0900 and 1000 hours.

The daily output of faeces was collected for five days of each week in bags fitted to each sheep. Faeces were dried at 80°C to a constant weight. The daily collections from each week were bulked for each sheep, mixed and sub-sampled for subsequent analysis.

Wool growth was measured from dyebands applied at approximately monthly intervals (Chapman and Wheeler 1963). Data for wool growth are expressed as g clean wool/sheep.day and have been corrected to allow for an emergence time of 7 days (Downes and Sharry 1971). Average fibre diameter was measured on 2 mm snippets at 4 sites along each wool staple on a Fibre Fineness Distribution Analyser.

Chemical analysis

Faecal and pasture samples were analysed for N by the Kjeldahl method and pasture samples were analysed for *in vitro* DM digestibility (IVD) by a modified pepsin-cellulase method (Klein and Baker 1993). This method gives a 1:1 estimate of digestibility *in vivo* and *in vitro* for a range of mature dry clovers.

Estimates of digestibility and N content of selected pasture

The input variables used in the computer simulation model GrazFeed version 1.1 (CSIRO 1990) were obtained from the experimental data as follows:

weight of green herbage on offer = total pasture on offer x proportion green; weight of dry herbage on offer = total pasture on offer x proportion dry; digestibility of green fraction = IVD of pasture at the beginning of the experiment; digestibility of dry fraction = IVD of pasture at the end of the experiment; proportion of legume in the sward was assessed visually each week; slope of land = 1.0 (ie. no slope); type of grasses present = volunteer; liveweight of sheep was measured each week; and age of sheep was 30 months. Based on these variables, estimates of the apparent digestibility and N content of selected pasture were derived.

Saul (1988) used sheep fitted with oesophageal fistulae to determine the relationships between the apparent digestibility and N content of pasture and the digestibility and N content of the diet that was selected. From his data we derived the following equations:

$y = 0.46 + 1.84\,x - 0.01\,x^2$ ($r^2 = 0.61$), where y = apparent digestibility of pasture selected and x = apparent digestibility of pasture on offer, and

$y = 0.72 + 1.48x - 0.14\,x^2$ ($r^2 = 0.67$), where y = N content of pasture selected and x = N content of pasture on offer.

Estimation of the intake of N and the amount of N apparently digested

The following equations were used to estimate the daily intake of DM (DMI), NI and ADN for each method of estimation:

DMI = total daily DM excreted in faeces / (1- digestibility of selected pasture) ... 1

NI = DMI (from equation 1) and N content of selected pasture ... 2

ADN = NI (from equation 2) - total daily N excreted in faeces ... 3

Statistical analysis

Data for each week describing pasture quantity and quality and liveweight of the sheep, and the estimated NI and ADN were analysed by repeated measures analysis of variance (Snedecor and Cochran 1980). Multiple comparisons between means were made using LSD when the F statistic from analysis of variance was significant. Wool growth data were analysed by analysis of variance.

RESULTS

Pasture quality and quantity

The average DM content of the Dinninup pasture remained constant at 16% until 16 October at which time it increased ($P < 0.01$) rapidly to 84%. We have assigned the onset of pasture senescence to 16 October because of this sharp and irreversible increase in the DM content. All other data on pasture characteristics are presented relative to the onset of senescence.

Prior to the onset of senescence, the IVD of pasture remained constant at 7578%. After the onset of senescence, IVD declined ($P < 0.05$) to 57% at an average rate of 0.64 percentage units/day.

The N content of the pasture on offer decreased ($P < 0.01$) prior to the onset of senescence from 4.0 to 3.2% of DM. With the onset of senescence, the rate of decrease in N content increased from 0.04 to 0.07 g N/100 g DM.day. Fourteen days after the onset of senescence the minimum N content was reached (1.6% of DM).

The amount of pasture on offer was 3.1 t DM/ha at the onset of pasture senescence. After the onset of senescence the amount of pasture available tended to decline slowly, although not significantly ($P > 0.05$), to 2.5 t DM/ha.

Estimates of digestibility and N content of selected pasture

Prior to the onset of senescence, the estimated DM digestibility of selected pasture derived from GrazFeed was 79-80%, while the estimates derived from Saul's (1988) data were 82-83%. The decline in digestibility after the onset of senescence was from 79 to 67% estimated using GrazFeed, and from 82 to 73% estimated from Saul's (1988) data.

The decline in the N content of selected pasture prior to the onset of senescence was from 4.2 to 3.5% estimated using GrazFeed and from 4.4 to 4.0% estimated from Saul's (1988) data. After the onset of senescence, the decline in the N content of selected pasture was from 3.4 to 1.8% estimated using GrazFeed and from 3.8 to 2.7% estimated from Saul's (1988) data.

Estimates of the intake of N and the intake of apparently digestible N

Nitrogen intake and ADN, as estimated by both methods, decreased ($P < 0.05$) prior to the onset of senescence but the rate of decline increased after the onset of senescence (Table 1). The greatest decline in NI and ADN occurred between 7 and 14 days after the onset of senescence. Although there were no significant differences ($P > 0.05$) between the estimated NI and ADN from the 2 methods, the estimates derived from Saul's (1988) data were consistently higher than the estimates derived from GrazFeed. Prior to the onset of pasture senescence this difference was about 16 g N/day, and with the onset of senescence the differences between the 2 methods increased; the estimates derived from Saul's (1988) data were about 23 g N/day higher than the estimates derived from GrazFeed.

Table 1. Nitrogen intake (NI) and apparently digested nitrogen (ADN) estimated by 2 methods (followed by SE of the mean)

Days from onset of senescence	NI (g N/day)				ADN (g N/day)			
	GrazFeed (CSIRO 1990)		Saul (1988)		GrazFeed (CSIRO 1990)		Saul (1988)	
-28	67	(7.2)	83	(9.0)	56	(5.9)	72	(7.7)
-22	64	(6.5)	79	(8.0)	54	(5.5)	69	(7.0)
-12	51	(4.1)	70	(5.6)	42	(3.4)	60	(4.9)
-7	56	(5.6)	72	(7.2)	45	(4.5)	61	(6.0)
0	45	(1.8)	68	(2.7)	35	(1.5)	59	(2.4)
7	39	(2.4)	63	(3.9)	30	(1.9)	54	(3.4)
14	27	(2.9)	52	(5.5)	18	(1.9)	42	(4.5)
21	29	(2.9)	50	(5.0)	18	(1.7)	39	(3.8)
28	25	(2.7)	48	(5.1)	14	(1.5)	36	(3.8)

For NI; values within a column that differ by more than 11.8, and values within a row that differ by more than 32.6, are significantly different ($P < 0.05$).
For ADN; values within a column that differ by more than 9.7, and values within a row that differ by more than 27.1, are significantly different ($P < 0.05$).

Wool growth and liveweight

One month prior to the onset of senescence wool growth was 13.2 (SE 0.72) g/day and the average fibre diameter was 25.7 (SE 0.78). Wool growth and fibre diameter decreased, although not significantly ($P > 0.05$), by the time the pasture began to senesce to 11.9 (SE 0.64) g/day and 24.9 (SE 0.44) μm. The first significant decrease ($P < 0.05$) in wool growth occurred between 23 and 44 days after the onset of pasture senescence when it decreased to 9.5 (SE 0.54) g/day. Similarly, the first significant difference in average fibre diameter occurred between 10 and 37 days from the onset of senescence when it decreased from 24.0 (SE 0.52) to 22.4 (0.51) μm.

Throughout the experiment, all sheep continued to increase in liveweight (from 52 to 60 kg; $P < 0.01$) although the general trend was for a decrease in the rate of liveweight gain from over 300 g/day before the pasture senesced to about 100 g/day after the pasture senesced.

DISCUSSION

Following the onset of pasture senescence, the rapid decline in the apparent digestibility and N content of pasture is in close agreement with the data from Hume and Purser (1975). However, there are differences between our estimates of NI and ADN and those measured by Hume and Purser (1975). They found that when penned sheep were fed cut pasture at approximately 90% of their *ad libitum* intake, NI and ADN dropped immediately after the pasture began to senesce. We found that the decline in NI and ADN estimated from GrazFeed and from Saul's (1988) data, declined most rapidly between 7 and 14 days after the onset of senescence. It appears that NI and ADN start to decline at a time that coincides with the maturation of the pasture prior to senescence but that the sheep were able to maintain a dietary intake with a higher N content than the average on offer for at least 3 weeks after the onset of pasture senescence.

The estimated NI and ADN derived from GrazFeed is lower than that derived from Saul's data. This difference is about 22% prior to the onset of pasture senescence and increases to over 60% by the end of the experiment. The green component of the pasture is particularly important in determining feed intake and animal production (t' Mannetje and Ebersohn 1980). In the later stages of this experiment only 10% of the pasture was green and only 10% was legume. Thus the differences in the predicted NI and ADN obtained from the 2 methods largely may reflect differences in the degree that the sheep apparently selected for green pasture.

Despite the decline in the ADN prior to the onset of senescence, when the pasture was still green, wool growth did not decrease until between 23 and 44 days after the onset of senescence. This delay in the decrease in the wool growth is likely to reflect 2 factors. First, there may be a lag between the decline in ADN and the response in wool growth response (Allden 1979) due to the use of amino acids mobilised from body reserves for wool growth (Revel1 1992). Second, when the pasture was still green, ADN would include about twice the amount of ammonia as when the pasture had senesced (Hume and Purser 1975) and this ammonia would not be available for wool growth. Thus non-ammonia N apparently digested in the small intestine may not decrease significantly until at least 3 weeks after the onset of pasture senescence. This suggests that providing supplements to sheep to minimise the decrease in wool growth observed at the end of spring may not be necessary until at least 3 weeks after the onset of pasture senescence, at a time when virtually all of the pasture is dry.

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