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Nutrient supply for lamb growth from Grasslands Puna chicory (Cichorium intybus) and Wana cocksfoot (Dactylis glomerata)

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ABSTRACT

Two groups of 10 intact Border Leicester ram lambs (10 weeks old; 22.7±0.59 kgLW) were grazed on either Grasslands Puna chicory (Puna) or Wana cocksfoot (Wana) over a six week period in late spring, to relate liveweight gain (LWG) to nutrient intake and supply at the duodenum from the 2 forages. Both pastures were in a vegetative state and offered at a high allowance (12.5 to 15 kgDM/lamb/d). Chemical composition (%DM) of oesophageal extrusa sample was 81.5 and 89.4 OM, 34.9 and 48.1 neutral detergent fibre (NDF) and 2.6 and 3.6 N and the *in vitro* OM digestibility was 72.6 and 74.2% for Puna and Wana respectively. Liveweight was recorded weekly and intake estimated in week 3 by reference to dilution of two faecal markers, Cr_2O_3 and Yb acetate. Digestion characteristics in the rumen and nutrient supply at the duodenum was measured in companion lambs (n=6) fitted with rumen and duodenal cannulae using Cr-EDTA and Yb acetate as the solute and particulate phase digesta markers, respectively.

LWG (g/d) was 268±20.9 on Puna and 205±19.1 on Wana. Digestible OM intake (DOMI) and nitrogen intake (NI) was lower on Puna (16.10 and 0.71 g/kgLW/d) than Wana (26.69 and 1.39 g/kgLW/d), and non-ammonia N (NAN) flow at the duodenum was similar (0.70 *v* 0.85g/kgLW/d) mainly due to variable N loss as ammonia across the rumen. It appears that the disparity in LWG of lambs grazing Puna and Wana may be related to differences in the balance of nutrients rather than the quantitative intake or supply of any one nutrient. This is shown in the ratio of duodenal NAN:DOMI which for Puna (43.5) was similar to legumes but the ratio for Wana (31.9) was lower than for other grasses. It is concluded tentatively that the nutritive value of Puna and Wana for lamb growth is best described by the NAN:DOMI ratio.

Keywords Lamb growth, chicory, cocksfoot,liveweight gain, nutritive value, intake, digestibility.

INTRODUCTION

Most lambs have a potential growth rate of 350 to 400 g/d. However lamb growth on pasture is poor in late spring and summer. In a survey of South Island properties Everest and Scales (1983) recorded post-weaning lamb growth rates of 84, 124 and 163 g/d on summer dry, summer moist and irrigated pastures respectively in December and January. Inadequate feed supply relative to requirement is an inherent limitation of seasonality in pasture feed supply to animal production in temperate regions (Christian 1987). Decline in feed quality of pasture due to approaching plant maturity in summer can also be a constraint on animal performance through its effect on herbage digestibility and intake (Waghorn and Barry 1987). There is evidence to show differences between forages in their ability to promote lamb growth with superior lamb growth on legumes compared to grasses and to associate these differences with the digestion chracteristics of the forages (Ulyatt 1981).

Higher summer yielding forage species are being evaluated as a means to alleviate the problem of low summer lamb growth rate. Wana cocksfoot is one such cultivar. It is relatively drought tolerant and capable of maintaining high pasture production later into summer (Hume and Fraser 1985) but information is lacking on its nutritive value for lamb growth. Grasslands Puna chicory is another forage being evaluated as a summer green feed. It has shown high DM yield in summer and preliminary grazing trials showed potential for producing high lamb growth (Fraser *et al.*, 1988).

This experiment was designed to compare post-weaning liveweight gain (LWG) of lambs grazing Puna chicory and Wana cocksfoot at a high allowance and to relate lamb growth to digestion and supply of nutrients from the two forages.

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MATERIALS AND METHODS

Two groups of 10 Border Leicester ram lambs averaging 10 weeks of age and 22.7 ± 0.59 kg liveweight were grazed on irrigated pastures of Puna chicory and Wana cocksfoot over a six week period from mid November to late December. Puna chicory had a total of 100kg urea-N/ha applied in two applications by November and Wana cocksfoot had 400kg urea-N/ha applied in early spring. Both pastures were maintained in as vegetative, pure species swards and offered in weekly subdivisions at herbage allowances of around 12.5 to 15 kgDM/lamb/d.

Liveweight of the lambs was recorded weekly. Herbage intake was estimated in week 3 from faecal output estimated from dilution of two markers, chromic oxide (Cr_2O_3) and ytterbium (Yb) acetate , and *in vitro* digestibility measured from oesophageal extrusa samples. Cr_2O_3 and Yb acetate were given in twice daily oral doses for 8 days and faecal samples collected from each lamb per rectum during the last 4 days of dosing as described by Cruikshank (1986).

Another group of lambs (n=6) each fitted with rumen and duodenal cannulae prior to the experiment were co-grazed on each forage during weeks 4 and 5 to measure digesta flow and nutrient supply at the duodenum. Chomium ethylene diamine tetra-acetic acid (Cr- EDTA) and Yb acetate were used as solute and particulate phase markers respectively (Siddons *et al.*, 1985). The continuous infusion and time sequence sampling technique of Faichney (1975) was used. The markers were infused into the rumen over a period of 7 days by portable peristaltic pumps from a reservoir of each marker on the back of each lamb. Duodenal digesta was sampled during the last two days of marker infusion 4 times per day. Intake of these cannulated lambs was also estimated from marker dilution in bulk faeces collected at the same time as digesta sampling and digestibility measured *in vitro*. Digestion and nutrient flow at the duodenum was determined by extrapolating digestion characteristics expressed in per kgLW/d measured over weeks 4/5 in the cannulated lambs to intake estimated in week 3 for the intact lambs.

The daily flow of OM, N and ammonia-N in duodenal digesta was calculated as described by Faichney (1975). Non-ammonia N (NAN) supply to the duodenum was the difference between total N and ammonia N flow. Duodenal OM flow was used to calculate the proportion of digestible OM intake (DOMI) apparently digested in the rumen (DOMADR). Mean concentration of rumen NH_3-N was determined from bulked rumen fluid samples collected during the last day of marker infusion at the same time as duodenal digesta sampling.

RESULTS

Herbage mass to ground level of Puna chicory was 9t DM/ha, 58% of which was leaf. Herbage mass of Wana cocksfoot averaged 3,100 ± 760 kg DM/ha over the 6 week grazing period. Analysis of oesophageal extrusa showed that leaf material represented 82 and 91% of herbage DM ingested and *in vitro* OM digestibility was 72.6 and 74.2% for Puna chicory and Wana cocksfoot respectively. The OM, NDF and N content (%DM) were 81.5, 34.9 and 2.6 for Puna chicory and 89.4, 48.1 and 3.6 for Wana cocksfoot respectively.

Lamb growth during 4 of the 6 weeks (Table 1) was higher on Puna chicory than Wana cocksfoot but the difference was not always significant. However the net effect over the 6 weeks was a 30% higher LWG ($p<0.05$) on Puna chicory (268g/d) compared to Wana cocksfoot (205g/d). The respective fasted liveweight gain was 235 and 163 g/d representing 88 and 80 % of LWG.

TABLE 1 Liveweight gain [a](g/d) of ram lambs grazing Puna chicory and Wana cocksfoot from mid Novmber to late December.

Pasture	Week 1	2	3	4	5	6	[b]Overall
Puna chicory	181.0	215.0	207.1	365.3	304.9	335.6	268.1
	±53.3	±67.6	±34.6	±22.3	±36.6	±58.2	±20.9
Wana cocksfoot	313.5	88.7	234.9	299.4	156.6	138.0	205.2
	±52.8	±33.6	±46.3	±29.4	±36.2	±38.2	±19.1
p<0.05	ns	ns	ns	ns	*	*	*

([a]) n = 10 for all values (mean, ± s.e.) within week except ([b]) n = 60. Difference between treatment (*) = significant or (ns) = not significant at p<0.05.

DOMI was 66% greater ($p<0.01$) on Wana cocksfoot compared to Puna chicory (Table 2) (a difference consistent for intake estimated over week 4/5 using cannulated lambs). N intake of lambs grazing Wana cocksfoot was twice as great as on Puna chicory. There was a large N loss (39.0%) as ammonia across the rumen with Wana cocksfoot but not for Puna chicory, resulting in almost similar NAN supply to the duodenum for both diets (Table 2). The ratio (g/kg) of NAN supply to DOMI was greater (43.5 v 31.9) for Puna chicory ($p<0.05$). A greater proportion (+15 %age units) of DOMI of Puna chicory was digested post-ruminally compared to that of Wana cocksfoot. The mean rumen NH_3-N concentration of lambs grazing Puna chicory was 50% less compared with lambs on Wana cocksfoot ($p<0.01$).

TABLE 2 Intake of digestible OM and N, rumen digestion indices and duodenal NAN supply for lamb growth from Puna chicory and Wana cocksfoot.

	Puna chicory	Wana cocksfoot	difference[b]
DOMI g/kgLW/d	16.10±1.69	26.69±4.52	**
[a]DOMADI %	48.6±1.70	63.6±1.90	**
N intake g/kgLW/d	0.71±0.007	1.39±0.002	**
duodenal NAN flow g/kgLW/d	0.70±0.007	0.85±0.001	*
[a]rumen NH_3-N mg/l	156.0±16.2	312.8±17.8	**
NAN:DOMI g/kg	43.5	31.9	

All values (mean±s.e.) are based on intake estimated in intact lambs (n=10) except ([a]) are from cannulated lambs (n=6). ([b]), significant difference at p<0.05 (*) or p<0.01 (**).

DISCUSSION

Herbage allowance on both pastures was very high compared to the allowance of 6 kgDM/lamb/d recommended for maximum herbage intake and lamb growth (Cruickshank 1986). It is therefore unlikely that intake was limited by feed availability.

Relative to the post-weaning LWG in the survey data of Everest and Scales (1983), lamb growth on Puna chicory and Wana Cocksfoot obtained in this experiment are high. Gut fill differences may explain a proportion of the difference in LWG but fasted liveweight gain was 44% higher on Puna than Wana. Cruikshank (1986) recorded lamb LWG of 227, 230, 308 and 321 g/d on ryegrass, prairie grass, lucerne and white clover respectively. These difference in LWG could be largely explained by differences in DOMI. In this work the greater LWG on Puna chicory was not associated with a higher DOMI compared with Wana cocksfoot. Similar observations were made by Beever *et al.*, (1988) and Thomas *et al.*, (1988) in a study on the provision of nutrients for growth in young cattle. These workers suggested an influence of the source of ME on animal performance. Thomas *et al.*, (1988) found that liveweight gain was inversely related to the proportion of ME derived from digestible cell wall. This hypothesis may help explain the higher LWG of lambs on Puna chicory which had a lower NDF content (34.9 %DM) than Wana cocksfoot (48.1 %DM).

Inefficient use of absorbed energy occurs on forage diets when the supply of glucose or its precursors, propionate and glucogenic amino acids are insufficient for the production of the co-factor $NADPH_2$ required for the biosynthesis of fatty acids from acetate (Black 1990). This nutrient status exists with high molar proportions of acetate production characteristic of poorer quality diets and is unlikely on high quality fresh pasture where forage species or season have little effect on acetate:propionate ratio (Beever *et al.*, 1986). The OMD of Puna chicory (72.6%) and Wana cocksfoot (74.2%) are high, consistent with other fresh forages (Ulyatt 1971), and the difference in digestibility is too small to expect any substantial difference in their molar proportions of acetate to explain the difference in the observed lamb growth. The energy cost of urea sysnthesis in the excretion of ruminal ammonia from the Wana cocksfoot diet may also have contributed to the lower lamb growth on cocksfoot.

The duodenal NAN supply from the two diets were similar due to variable ammonia N loss. Thus, in a non-energy limiting situation, similar growth rate might be expected on both forages but this was not the case. Digestion characteristics of Wana cocksfoot (Table 2) is consistent with DOMADR of 60% (Beever and Siddons 1986) and N losses of 30 to 40% across the rumen (Ulyatt *et al.*, 1988, Fraser *et al.*, 1990) commonly observed for fresh forage diets whereas N loss for Puna chicory is very low and the DOMADR is lower than from Wana cocksfoot. Microbial protein is therefore likely to constitute a larger proportion of the duodenal NAN flow for Wana cocksfoot than Puna chicory. Storm and Orskov (1984) have shown that microbial protein is limiting in some essential amino acids for growth which may have disadvantaged lambs grazing Wana cocksfoot despite similar NAN supply as on Puna chicory. Furthermore N loss on Puna chicory is similar to that for protected protein N (Beever and Siddons 1986) indicating a duodenal NAN flow consisting of N of largely dietary origin and possibly a better balance of essential amino acids.

Although rumen NH_3-N concentration from Puna chicory (156.0mg/l) was lower than on Wana cocksfoot (312.8mg/l) it is above the minimum concentration for maximum rates of rumen digestion (125mg/l; Odle and Schaefer 1987) or microbial growth (50mg/l; Satter and Slyter 1974). The high rumen NH_3-N concentration from Wana cocksfoot lambs suggests an imbalance of N release to readily fermentable OM for efficient rumen microbial metabolism (Beever *et al.*, 1986) resulting in a large N loss between the mouth and duodenum. In contrast the negligible loss of N from the Puna chicory diet suggests a more efficient microbial protein synthesis (Ulyatt *et al.*, 1975) and its supply at the duodenum perhaps enhanced by a high rumen dilution rate (Harrison *et al.*, 1975).

A low efficiency of utilisation of ME for growth in both lambs and young cattle on pasture can be expected when a low ratio of amino acid N:ME of absorbed nutrients exists (Beever t al 1986, Cruikshank 1986). Cruickshank (1986) reported NAN:DOMI ratios of 45.0 and 41.0 with LWG of 314 and 229 g/d for lambs grazing legumes or grasses respectively. On the basis of the NAN:DOMI ratio Puna chicory appears to rank between legumes and grasses while Wana cocksfoot is marginally below other grasses in its nutritive value for lamb growth. The lamb growth rates support this hypothesis. Differences in efficiency of ME utilisation for growth may indicate differences in the ratio of fat to protein deposited (Black 1990). As a result of the low NAN:DOMI ratio, it is possible that the lower LWG relative to the high apparent DOMI on Wana cocksfoot may be associated with a higher proportion of fat and energy retained per unit LWG (Rattray and Joyce 1985), compared to Puna chicory.

CONCLUSION

Lamb growth rate on Puna chicory was greater than on Wana cocksfoot. The difference in growth rate was not adequately explained by differences in level of N digestion and supply at the duodenum or DOMI. The relative nutritive value of these two herbages for lamb growth was related to the supply of duodenal NAN:DOMI ratio. An assessment of the nature of the duodenal NAN and ME intake, and body composition and energy changes might help to further explain the reasons for the difference in growth rate.

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