THE POTENTIAL OF SULLA IN PASTURE-BASED SYSTEMS

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SUMMARY
A feed evaluation trial compared lamb growth, rumen function and protein synthesis from either pasture (perennial ryegrass (*Lolium perenne*)/white clover (*Trifolium repens*)-dominant), lucerne (*Medicago sativa*), sulla (*Hedysarum coronarium*, which contains condensed tannins (CT)) or a lucerne:sulla mixture. The 8 week trial involved 32 weaned ram lambs allocated to either pasture (80% ryegrass and 20% white clover), lucerne, sulla, or a 50:50 lucerne:sulla mixture (DM basis; 8 per diet). Measurements included feed intake, liveweight (LW) gain, rumen ammonia (NH_3) and volatile fatty acid (VFA) concentrations. A sub-group of 16 lambs (4 from each treatment) were given a continuous infusion of ^{35}S-cysteine and ^{35}S-sulphate to measure the effect of diet on cysteine irreversible loss and absolute whole body protein synthesis (WBPS). Lambs fed pasture had the slowest ($P<0.05$) daily gains (116 g/day) and absolute WBPS (93 g/day) compared with lambs fed sulla (308 g LW and 152 g WBPS/day) or lucerne:sulla (281 g LW and 180 g WBPS/day). Lambs fed sulla had lower rumen NH_3 concentrations (13.6 mmol/L), acetate:propionate ratios (2.6) and minor VFA concentrations (2.1%) suggesting less rumen proteolysis than lambs fed the other diets. Lamb performance was improved by feeding sulla or lucerne compared to pasture, and the lucerne:sulla mixture resulted in better performance than the average of the 2 species fed alone.

Keywords: liveweight gain, pasture, lucerne, sulla, condensed tannins, whole body protein synthesis

INTRODUCTION
New Zealand's livestock industries are reliant on perennial ryegrass (*Lolium perenne*)/white clover (*Trifolium repens*)-dominant pastures, but they are not always ideal for meeting nutrient requirements because high fibre concentrations limit intakes, protein is very rapidly degraded and readily fermentable carbohydrate concentrations are low. Significant improvements in animal performance are achievable by feeding forages other than perennial ryegrass-dominant pasture. Lucerne (*Medicago sativa*) and sulla (*Hedysarum coronarium*) are legumes with a nutrient composition that supports a high feeding value. Sulla has a high concentration of soluble carbohydrate (18-25% DM) and contains condensed tannin (CT) which reduces rumen proteolysis (McNabb *et al*. 1996) to increase the flow of amino acids to the small intestine (Bermingham *et al*. 2001). This biennial legume has promoted high intake and liveweight (LW) gains in lambs (Terrill *et al*. 1992; Stienezen *et al*. 1996). However, 88 g CT/kg DM reduced the daily gain in lambs (Douglas *et al*. 1999). When dietary CT exceeds 4-6% of dietary DM, intake and performance may be reduced, depending upon the chemical structure and source of CT (Waghorn *et al*. 1990). Sulla could be fed with more fibrous and high protein forages (e.g. lucerne) as a means of diluting dietary fibre, supplying soluble carbohydrates to rumen bacteria and increasing protein supply to the small intestine. The objective of this study was to compare animal performance of lambs fed 4 contrasting forages and determine whether complementing lucerne with sulla had advantages for animal performance.

MATERIALS AND METHODS
The information presented here is part of a larger experiment (Burke *et al*. 2002) and reports LW gain, feed intake and rumen parameters (ammonia, NH_3; volatile fatty acids, VFA) of lambs fed pasture (80% ryegrass:20% white clover), lucerne, sulla, and 50% lucerne/50% sulla, and absolute whole body protein synthesis (WBPS) from a subset of lambs (16 lambs). The experimental procedures were reviewed and approved by the Crown Research Institute, Animal Ethics Committee in Palmerston North, New Zealand.

Animals and diets
Thirty-two weaned ram lambs (aged 12 weeks, and 28.5 ± 0.13 kg) were fed *ad-libitum* for 8 weeks from 19 October to 18 December 2000. All forages were in a vegetative state and were harvested daily by sickle bar mower and chopped to 3-6 cm lengths using a JF Forage chopper (Model FC80) to facilitate accurate mixing and feeding.

Each dietary treatment group was made up of 8 lambs held on sawdust feed pads (10 m x 3 m) and provided with shelter and water. Each group was given their daily allowance at about 1100 h and refusals were about 15% of feed offered. Samples of fresh forage and refusals were collected throughout the trial, frozen and freeze-dried to determine chemical composition by Near Infra Red Spectrometry (NIRS) to calculate intakes of DM and DM constituents.

Lambs were weighed weekly prior to feeding, at about 0900 h. Wool yields and carcass weights are reported by Burke *et al*. (2002). Rumen contents (20 mL) from each lamb were obtained by lavage (stomach tube) on days 9, 14, 21, 29, 35 and 42 of the experiment, 2-4 h after feeding for VFA analysis by gas-liquid chromatography (Attwood *et al*. 1998) and NH_3 determination using a commercial kit (Cat. # 171-C; Sigma Chemicals).

Absolute whole body protein synthesis
Four lambs from each dietary treatment were bought indoors to metabolism crates from day 47 to 65 of the trial, fitted with jugular catheters and infused with [^{35}S]-cysteine and [^{35}S]-sulphate to estimate WBPS. Each lamb received an 8-hour continuous infusion of $Na^{35}S\text{-}SO_4$ (55.5 MBq/lamb; 49.8 kBq/min) to determine the irreversible loss rate (ILR) of sulphate. After 4 days, to enable clearance of sulphate, an 8-hour continuous infusion of ^{35}S-cysteine (46.3 MBq/lamb; 32.3 kBq/h) was given to measure cysteine ILR and calculate WBPS according to Lee *et al*. (1995).

Cysteine concentration was determined using acid ninhydrin (Gaitonde 1967) and plasma sulphate concentration by HPLC by ion exchange chromatography. Total radioactivities of ^{35}S-cysteine and ^{35}S-sulphate were determined by mixing 100 µL of sample with 2 mL of scintillation mixture (Starcint, INSUS Systems) according to the method of Lee *et al*. (1995). The proportions of total radioactivity attributed to ^{35}S-cysteine and ^{35}S-sulphate in samples were determined with an inline liquid scintillation counter (Model 2, ßram IN/US systems Inc., New Jersey, US) coupled to a HPLC (LC4a, Shimadzu, Kyoto, Japan) according to the method of Lee *et al*. (1995).

The specific radioactivity (SRA) of sulphate and cysteine, ILR and the transfer of cysteine to sulphate were calculated using the equations described by McNabb *et al*. (1993). Total fluxes through the cysteine and sulphate pools were calculated and cysteine ILR, less oxidation, was used to determine absolute WBPS (g/day) by assuming a cysteine concentration of 36.2 g/kg total amino acid (MacRae *et al*. 1993).

Statistical analysis
Effects of diet on all parameters were determined using the GLM procedure of SAS (1996). Probability (P) values less than 0.10 indicated a significant effect for absolute whole body fluxes through the cysteine and sulphate pools, but $P<0.05$ indicated a significant effect for all other measurements.

RESULTS
Feed composition
Nutrient composition of pasture, lucerne and sulla (g/kg DM), respectively, was 121, 123 and 218 g soluble carbohydrate; 155, 244 and 192 g crude protein; 480, 323 and 151 g neutral detergent fibre; and 10.1, 11.8 and 12.2 MJ metabolisable energy/kg DM. The composition of lucerne:sulla offered was the average of the individual diets. Concentrations of total CT averaged 56 and 28 g/kg DM in sulla and lucerne:sulla, respectively.

Lamb performance
Feed intake and animal performance are shown in Table 1. Pasture-fed lambs grew at 116 g/day over the duration of the trial and achieved a final LW of 34.5 kg, which was significantly lower than all other treatments. Lambs fed sulla and lucerne:sulla had the most rapid daily gain, achieving final LW

of 43.3 – 43.4 kg. Intakes of lambs fed sulla and lucerne:sulla were higher than those fed pasture or lucerne.

Rumen ammonia, volatile fatty acids and pH

Rumen NH_3 concentration was highest in lambs fed lucerne and lowest in lambs fed sulla, while adding sulla to lucerne significantly reduced rumen NH_3 concentrations (Table 1). Lambs fed pasture and sulla had lower concentrations of rumen VFA (Table 1), but sulla and lucerne:sulla had a higher percentage of propionate (24 and 21%) and butyrate (12 and 11%), with less acetate (62 and 64%) compared with lambs fed pasture and lucerne (17 and 20% propionate; 9 and 8% butyrate; 70 and 68% acetate, respectively).

Table 1. Effects of dietary treatment on feed intake, liveweight (LW) gain, whole body (WB) cysteine and sulphate fluxes and absolute WB protein synthesis. Least squares means ± s.e.m. are reported.

	Pasture	Lucerne	Sulla	Lucerne:sulla	s.e.m.	P
Feed intake on feed pads (kg DM/day)	1.10	1.37	1.47	1.54	-	-
LW gain (g/day)^A	116^a	207^b	308^c	281^c	14.2	< 0.01
Rumen NH_3 (mmol/L)	17.0^a	27.5^b	13.6^c	16.0^a	0.75	< 0.01
Rumen VFA (mmol/L)	79.2^a	101.3	82.2^a	90.3^c	2.31	< 0.01
Whole body fluxes						
LW at start of infusions (kg)	30.7^a	35.8^b	38.4^{bc}	40.0^c	0.87	< 0.01
Feed intake during infusions (kg DM/day)	1.03	1.63	1.60	1.66	0.052	< 0.01
Cysteine entry; ILR (μmol/min)^A	21.6^a	34.7^b	36.7^b	41.4^b	9.25	< 0.06
Cysteine to productive purposes (μmol/min)	19.2^a	31.3^b	31.6^b	37.4^b	8.40	< 0.07
Protein synthesis (g/day)	92.6^a	150.7^b	152.3^b	180.0^b	40.50	< 0.07

Means within rows with different subscripts are significantly different ($P<0.05$ or $P<0.10^A$)

Absolute whole body protein synthesis

Cysteine ILR (μmol/min) was lower in lambs fed pasture compared with those fed the other diets, with low oxidation rates (2.5 μmol/min) relative to other treatments (3.4-5.0 μmol/min). Consequently, lambs fed pasture had the lowest flux of cysteine to productive purposes and lower absolute WBPS (g/day) than lambs fed other diets (Table 1).

DISCUSSION

Feeding sulla and lucerne:sulla improved growth of young lambs compared with lambs fed pasture or lucerne. Sulla had a similar feeding value to white clover (Burke *et al*. 2002), and the feeding value of lucerne was improved when complemented with sulla. Growth of lambs in this study complement those of Terrill *et al*. (1992) who suggested the difference in LW gain was due to a higher ratio of readily fermentable to structural carbohydrates in sulla, compared with pasture, and a rapid rumen clearance rather than an effect of CT. Evidence in this study suggests that both CT and readily fermentable carbohydrate content of sulla contributed to the performance of lambs fed sulla and lucerne:sulla. High feed intakes obtained in these lambs confirm rapid rumen clearance, and the low concentration of CT (56 g/kg DM) in sulla was not detrimental to intake. Sulla may have complemented lucerne because it diluted the fibre, added soluble carbohydrates, and reduced protein degradation, but it did not result in daily gains comparable to lambs fed sulla or white clover as a sole diet (Burke *et al*. 2002).

Effects of dietary treatment on LW gain supported WB cysteine ILR and protein synthesis in pasture-fed lambs compared with lambs fed the other diets, however, there was no significant difference between lucerne, sulla and lucerne:sulla, despite LW gain differences. Cysteine ILR of lambs fed pasture in this study was similar to reports from Lee *et al*. (1995), while the cysteine ILR of lambs fed sulla and lucerne:sulla were comparable to sheep fed *Lotus pedunculatus* (McNabb *et al*. 1993).

The reduced rumen proteolysis in lambs fed sulla, as indicated by the lower rumen NH_3 and minor VFA concentrations (iso-butyric, iso-valeric and n-valeric acids), was due to the presence of soluble carbohydrates and/or CT in sulla. When sulla was mixed with lucerne, the high concentration of soluble carbohydrate in sulla may have improved the capture of NH_3 arising from proteolysis, increasing microbial growth and flow from the rumen (Dellow *et al*. 1988). Condensed tannin from 1 plant species is able to bind with and precipitate protein from another species both *in vitro* and *in vivo* (Waghorn and Jones 1989; Min *et al*. 2000). Therefore, the impact of a high soluble carbohydrate concentration should complement the effects of CT with diets containing a high protein concentration (eg. lucerne) because the CT will limit proteolysis (Waghorn *et al*. 1994; McNabb *et al*. 1996).

Adding sulla to lucerne at a 50:50 ratio improved lamb LW gain to a greater extent than the average for each diet fed alone and demonstrates the advantages of feeding complementary forages to provide an optimum supply of nutrients to meet nutrient requirements for growth. Lamb performance was supported by rumen and protein synthesis data. Not all forages are complementary as Burke *et al*. (2002) reported no advantages of combining sulla with white clover, but there were advantages of combining sulla and pasture.

CONCLUSION

Lamb performance can be improved by feeding sulla, and when mixed with lucerne, substantial benefits can be achieved. Compared with pasture, improved performance could be due to increased intakes as well as an appropriate balance of nutrients. Inclusion of sulla in farming systems requires specialist management, but its high yield makes it a valuable crop for lamb finishing.

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