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## Effects of condensed tannins on animal performance in lambs grazing Yorkshire fog (*Holcus lanatus*) and annual ryegrass (*Lolium multiflorum*) dominant swards

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### ABSTRACT

A comparative study was undertaken in Uruguay from August to early November 1994 to investigate differences in animal performance between lambs rotationally grazing mixed swards of annual ryegrass (*Lolium multiflorum*) and white clover (*Trifolium repens*) or Yorkshire fog (*Holcus lanatus*) and *Trifolium repens*. The effects of condensed tannins (CT) on lamb production were assessed by twice daily oral administration of polyethylene glycol to half the lambs on each sward combination. Lambs grazing on Yorkshire fog swards had higher clean wool growth (1470 vs 1280 ± 39 µg cm<sup>-2</sup> day<sup>-1</sup>, P < 0.01), greater liveweight gains (152 vs 108 ± 5.5 g day<sup>-1</sup>, P < 0.001), final weight (42 vs 38 ± 0.5 kg, P < 0.001), and carcass weight gains (89 vs 69 ± 2.5 g day<sup>-1</sup>, P < 0.001) than lambs grazing annual ryegrass swards. Slightly higher condensed tannin (CT) dietary concentrations were recorded in Yorkshire fog swards than in annual ryegrass (0.420 vs 0.365 ± 0.021% on a DM basis, P < 0.08). These low CT levels increased clean wool growth (1440 vs 1310 ± 32 µg cm<sup>-2</sup> day<sup>-1</sup>, P < 0.05) and liveweight gains (141 vs 120 ± 4.3 g lamb<sup>-1</sup> day<sup>-1</sup>, P < 0.01). The effects of CT on animal performance were greater in Yorkshire fog swards. The results of this experiment indicate (i) the advantage of Yorkshire fog over annual ryegrass for lamb production under moderate to low soil fertility conditions, and (ii) CT concentrations in forage diets close to 0.5% on DM basis are the minimum needed to significantly improve ruminant production.

**Keywords:** annual ryegrass (*Lolium multiflorum*); Yorkshire fog (*Holcus lanatus*); white clover (*Trifolium repens*); birdsfoot trefoil (*Lotus corniculatus*); polyethylene glycol (PEG); condensed tannins (CT); lamb growth; wool growth.

### INTRODUCTION

In previous studies on Yorkshire fog (*Holcus lanatus* L.) and perennial ryegrass (*Lolium perenne* L.) swards, low dietary concentrations of condensed tannins (CT; 0.18 to 0.2% on a DM basis) had small and non-persistent effects on sheep production (Montossi et al., 1994; Montossi, 1995). Further moderate increases in the concentration of CT in those swards by the concentrating effects of nutrient-poor habitats (Lowther et al., 1987) or by the inclusion of species containing higher levels of CT (eg *Lotus corniculatus*; Douglas et al., 1995) might enhance animal performance. In addition, Yorkshire fog and *Lotus corniculatus* are of particular interest for the Basaltic soils of Uruguay.

### MATERIALS AND METHODS

This experiment was carried out from August to November 1994 at the Glencoe Research Unit (latitude 32°01'32" S, 57° 00' 39" W) of the INIA-Tacuarembó Research Station, in an extensive region of Basaltic soils in central-north Uruguay. The predominant soil types on the experimental site are silty clay loam (Typic brown-reddish and black Litosoles), shallower than 50 cm with stone content (Berreta, personal communication). The original phosphorus status was very low (1.75 ± 0.5 µm/g Resinas-P). The area received an application of 68 and 175 kg ha<sup>-1</sup> of P<sub>2</sub>O<sub>5</sub> and NH<sub>3</sub> respectively in April 1994.

Four mixed swards were sown in April 1994 with annual ryegrass (*Lolium multiflorum* L. cv. 'INIA Estanzuela 284') or Yorkshire fog (*Holcus lanatus* L. cv. 'INIA La Magnolia') both combined with white clover (*Trifolium repens* L. cv. 'INIA Estanzuela Zapicán'), and with or without birdsfoot trefoil (*Lotus corniculatus* L. cv. 'INIA Estanzuela San Gabriel'). Seeding rates were 17, 8, 3.6 and 8.5 kg/ha<sup>-1</sup> for annual ryegrass, Yorkshire fog, white clover and lotus respectively. The four swards were randomly allocated within four replicate blocks of 0.7 ha in a complete randomised block design (CRB). Individual plots of 0.175 ha were further sub-divided into four sub-plots, which were grazed in rotation for periods of 7 days. During June, all plots were grazed down to approximately 5 cm by drenched adult sheep for two days, then left to accumulate herbage until the trial commenced on 1 August.

Ninety six castrated Corriedale lambs, approximately 10 months old and mean liveweight 29 ± 3.9 kg were divided randomly into balanced groups of 6 lambs according to fasted initial liveweight and assigned to four sward treatments in each block one week before measurements commenced. At plot level, half (n = 3) of the lambs received a twice daily oral administration (0730 and 1730 hours) of polyethylene glycol (PEG; MW 4,000), whilst the remaining lambs (n = 3) received oral administration of an equivalent volume of water. Daily doses of PEG of 60 g in 120 ml water and of 20 g in 40 ml water per lamb were used for treatments with and without lotus respectively.

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Herbage mass and its botanical composition were estimated monthly by cutting ten 0.1 m<sup>2</sup> quadrats in each plot at random before and after grazing. Thirty sward surface height readings were randomly recorded before and after grazing in each plot using a common ruler. These sward height estimates were used to adjust animal numbers.

Unfasted lamb liveweight was recorded weekly and 24 hours prior to slaughter (November). Hot carcass weight and the total tissue thickness (GR; Kirton, 1989) on both sides of the hot carcass were recorded. Wool growth was estimated at 6 week intervals by clipping 10 x 10 cm patches to skin level on the right midside of all the animals while they lay on a flat surface (Bigham, 1974).

Four pairs of oesophageally fistulated sheep were rotated between blocks and plots on a daily basis in a balanced sequence. Extrusa samples were collected and analysed for CT and their fractions (Terrill *et al.*, 1992) and OM digestibility (OMD) (Roughan and Holland, 1979).

The pasture and animal data were analysed using the statistical package SAS (SAS Institute, 1985), based on a Split-Split-Plot in time design using 4 blocks, with swards as the main plot arranged in a 2 x 2 factorial structure, grasses being one factor and lotus (presence or absence) the other factor. PEG (CT inactivated or activated) was treated as the split-pot factor, while time was used as the split-split-plot factor.

### RESULTS AND DISCUSSION

Sward and animal results are summarised for the entire experimental period in Table 1-3. Given the small contribution of lotus to the experimental swards (range 0 - 1.6% on green DM basis) and to the diets (Montossi, 1995), the effects of the main grass species are meaned across ± lotus treatments in these tables.

#### Sward measurements

The pre-grazing herbage mass and dead components were higher for annual ryegrass swards than for Yorkshire fog swards. These differences persisted during grazing, but became much smaller, especially in the mass of dead herbage (Table 1). However, within the green herbage

mass component, the pre- and post-grazing proportions of green leaf were consistently greater for Yorkshire fog swards than for annual ryegrass, resulting in similar amounts of green leaf, with correspondingly greater proportions and amounts of green stem for annual ryegrass swards. The pre- and post-grazing sward surface heights of both swards followed the trend observed for herbage mass (Table 1).

Sown grasses formed the major component of both grass treatments before and after grazing. No Yorkshire fog plants appeared in the samples from ryegrass swards, but annual ryegrass made a substantial contribution to Yorkshire fog swards (Table 1), probably related to the presence of seed-banks associated with the previous cultivation of this species on the experimental site. Legumes made minor contributions to herbage mass in both swards.

The higher contents of dead material and green stem in annual ryegrass swards compared to Yorkshire fog swards were a consequence of the early reproductive development of annual ryegrass, which normally starts in early October in Uruguay, in contrast to the reproductive development of Yorkshire fog tillers in late November and early December (E. Berreta, personal communication).

#### Animal measurements

The digestibility of the herbage consumed by OF sheep was consistently higher on Yorkshire fog swards than on annual ryegrass swards, while acid detergent fibre (ADF) and lignin were significantly higher ( $P < 0.05$ ) on ryegrass swards (Table 2) in accord with increasing maturity of both leaf and stem fractions.

The presence of low concentrations of CT (0.37% on a DM basis) in diets from annual ryegrass swards (Table 2), together with the evidence obtained by Montossi *et al.* (1994), Montossi (1995), and Liu *et al.* (unpublished) confirming also their presence in *Lolium perenne*, suggests that the entire *Lolium* genera may contain CT. Horigome and Uchida (1981) also found CT in trace amounts in leaves of annual ryegrass. The CT concentration (0.42% on a DM basis) observed in Yorkshire fog diets (Table 2) is much higher than that previously reported for this species from either cut herbage or extrusa

**TABLE 1:** Herbage mass (kg DM ha<sup>-1</sup>) and its botanical composition (% on green DM basis) and sward height (cm) for each treatment before and after grazing.

Sward components	Before grazing			After grazing		
	Annual ryegrass	Yorkshire fog	SEM	Annual ryegrass	Yorkshire fog	SEM
Herbage mass	5820	4360	190***	4160	3340	125 **
Sward height	29	21	0.6***	15	12	0.3***
Proportions (%)						
Ryegrass	69	25	1.8***	65	25	2.8***
Yorkshire fog	0	46	1.6***	0	37	1.5***
White clover	2.4	3.0	1.1	0.2	0.2	0.3
Birdsfoot trefoil	0.5	1.1	0.2*	0.1	0.7	0.2
Weeds	0.6	1.5	0.4	0	1.5	0.3*
Dead material	27	22	0.8**	34	34	2.3
Green leaf	62	73	1.4**	40	56	2.6**

Significance = \* $P < 0.05$ , \*\*  $P < 0.01$  and \*\*\*  $P < 0.001$

**TABLE 2:** Chemical composition (% DM) of the diet selected by oesophageal fistulated wethers for each grass treatment.

Diet selection	Annual ryegrass	Yorkshire fog	SEM
Organic matter digestibility	74	78	0.8*
Neutral detergent fibre	49	47	0.7
Acid detergent fibre	25	23	0.5*
Lignin	2.4	1.7	0.1**
Ash	15.6	15.8	0.3
Condensed tannin			
Free	0.082	0.093	0.005
Protein-bound	0.161	0.198	0.019
Fibre-bound	0.122	0.129	0.007
Total	0.365	0.420	0.021

Significance = \*  $P < 0.05$ , \*\*  $P < 0.01$  and \*\*\*  $P < 0.001$ .

samples (Terrill *et al.*, 1992a, b; Douglas *et al.*, 1993; Montossi *et al.*, 1994; Iason *et al.*, 1995; Montossi, 1995; Liu *et al.*, unpublished). The low fertility conditions of the experimental site in the present study probably explain this effect. Increased concentrations of CT have been found in CT-containing legumes under environmental stress (Barry and Forss, 1983; Douglas *et al.*, 1993). Total CT and their components did not differ significantly between swards, but tended to be higher in Yorkshire fog.

Lambs grazing Yorkshire fog swards had significantly higher midside clean wool growth rates than lambs grazing on ryegrass swards ( $P < 0.01$ ) (Table 3). Liveweight gains on Yorkshire fog swards were consistently higher ( $P < 0.001$ ) than those on annual ryegrass swards, resulting in significantly greater final weights ( $P < 0.001$ ), carcass gains ( $P < 0.001$ ), carcass weights ( $P < 0.001$ ), and GR values ( $P < 0.001$ ). Lamb production per unit area was also 25% higher for Yorkshire fog swards than for annual ryegrass swards (Montossi, 1995). The differences resulted principally from the effects of the higher OMD values (Table 2) and herbage intakes (Montossi, 1995) on Yorkshire fog swards compared to those on annual ryegrass, reflecting the higher dietary proportions of green leaf and the lower proportions of green stem and dead material in Yorkshire fog swards.

Clean wool growth ( $P < 0.05$ ), liveweight gains ( $P < 0.01$ ) and final weights ( $P < 0.10$ ) were greater in non-PEG lambs than in PEG lambs (Table 3), respectively, though differences in carcass characteristics were usually modest and non significant. These findings follow the tendencies observed in the spring trial of Terrill *et al.*, (1992b) with similar levels of CT in the diet to those of the present experiment. A significant grass x PEG interaction (Table 3) indicated that CT in Yorkshire fog was more effective than CT in annual ryegrass in promoting increase in liveweight gain. There was a similar, though non-significant interaction for wool growth (Table 3) an effect which was also observed in an earlier comparison of perennial ryegrass and Yorkshire fog (Montossi *et al.*, 1994). The greater wool production of non-PEG lambs was probably a response to improvement in the efficiency of utilisation of dietary nitrogen linked to the protective effect of CT, though it cannot necessarily be assumed that this was the sole effect of PEG on digestive function. However, the beneficial effect of CT on wool production has been well documented in the literature (Waghorn *et al.*, 1990; Lee *et al.*, 1992; Wang *et al.*, 1994).

## CONCLUSIONS

This study indicates the potential advantage for lamb production of Yorkshire fog swards compared with annual ryegrass swards under low to moderate soil nutrient conditions.

CT dietary concentrations (0.36 - 0.42% on a DM basis), increased wool production and liveweight gains by 10 to 15% in both swards, but to a greater extent in lambs grazing on Yorkshire fog swards, indicating that (i) probably CT concentrations in forage diets close to 0.5% on a DM basis are the minimum to significantly improve animal production, and (ii) apparently CT present in Yorkshire fog are more efficient in binding plant proteins than those of annual ryegrass. The reasons for this apparent difference in response to CT between grasses require further investigation.

**TABLE 3:** The effect of grass treatment and PEG supplementation on clean wool growth ( $\text{g cm}^{-2} \text{day}^{-1}$ ), liveweight gain ( $\text{g day}^{-1}$ ), final liveweight (kg), carcass weight (kg), carcass gain ( $\text{g lamb}^{-1} \text{day}^{-1}$ ), GR (mean value of left and right sides, mm) and dressing out (%).

Animal parameters	Annual ryegrass		Yorkshire fog		SEM	Main effects and interaction		
	+ PEG	- PEG	+ PEG	- PEG		Grass	PEG	Grass x PEG
Wool growth <sup>1</sup>	1220	1343	1377	1535	30	**	*	NS
Liveweight gain <sup>1</sup>	105	111	134	173	4.3	***	**	*
Final liveweight <sup>1</sup>	37.7	38.5	41.9	43.0	0.5	***	NS	NS
Carcass weight <sup>1</sup>	17.0	17.0	18.7	19.3	0.3	***	NS	NS
Carcass gain <sup>1</sup>	68.0	70.0	85.9	91.7	2.5	***	NS	NS
GR <sup>2</sup>	7.0	8.7	11.5	10.0	0.5	**	NS	NS
Dressing out <sup>2</sup>	44.9	44.3	44.8	44.9	0.4	NS	NS	NS

Significance = \*  $P < 0.05$ , \*\*  $P < 0.01$ , \*\*\*  $P < 0.001$  and NS (Not significant)

<sup>1</sup> Initial measurements at the beginning of the trial were used as covariate

<sup>2</sup> Carcase weight used as covariate.

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