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Can mating ewes on condensed tannin-containing forages be used to reduce lamb mortality between birth and weaning?

T.N. BARRY, T.J. PARKINSON, C.A. RAMIREZ-RESTREPO, E.L. McWILLIAM AND N. LOPEZ-VILLALOBOS

Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North, New Zealand

ABSTRACT

Five grazing experiments are described where ewes were fed forages which are likely to increase the absorption of essential amino acids (EAA) for periods of 63-70 days, immediately before and during mating, relative to control ewes mated on grass based pastures. The legume *Lotus corniculatus* (Birdsfoot trefoil CV Grassland Goldie) was fed in two experiments and supplements of willow or poplar forage trees were given to ewes mated on low quality drought pasture in three experiments. Both *L. corniculatus* and the forage trees contained condensed tannins (CT) and in addition the crude protein content of the forage trees (166 g/kg DM) was much higher than that of drought pasture (122 g/kg DM).

Mating on *L. corniculatus* and supplementing with forage trees consistently increased lambing percentage. Lamb mortality between birth and weaning was significantly reduced ($P<0.05$) by mating on *L. corniculatus* in one experiment and by feeding forage trees during mating in one experiment. Similar trends of smaller magnitude were evident in the other experiments and did not attain statistical significance.

Hypotheses of how feeding these forages during mating may have reduced post-natal lamb mortality are advanced and methods of testing the hypotheses are suggested.

Keywords: Lamb mortality; *Lotus corniculatus*; forage trees; condensed tannins.

INTRODUCTION

Lamb mortality between birth and weaning is both an economic loss and a potential future welfare issue in New Zealand (NZ). Typical losses are 15% for single born lambs, 25% for twins and 35% for triplets. With 26 million lambs slaughtered in 2003 in NZ, the industry is valued at $1.6 billion per annum (Meat and Wool Innovations Economic Service, 2003). Any technique that reduced average lamb mortality from 20% to 15% (i.e. a 25% reduction) would increase export income by $105 million. The potential of mating ewes whilst consuming condensed tannin-containing forages for reducing post-natal lamb mortality will be discussed in this contract presentation.

FORAGE CONDENSED TANNINS

Condensed tannins (CT) are secondary plant compounds that occur in some specialised legumes and are generally present in forage trees; they occur in only trace amounts in the common grasses and legumes that are used for feeding ruminant livestock in NZ. CT are not nutrients themselves; rather they are of nutritional benefit in fresh forages fed to ruminants because of their reversible reactivity with forage proteins (Barry & McNabb, 1999). The CT-protein complex is stable at rumen pH (6.0 – 7.0) and reduces protein degradation to ammonia by rumen microorganisms; the complex disintegrates at abomasal pH (2.5 – 3.5), making the protein potentially available for absorption in the small intestine and thereby increases the quantity of amino acid absorbed. CT in a range of plant species have different reactivity with proteins and some forage CT are therefore better than others at increasing net absorption of essential amino acids (EAA) in ruminants fed fresh forage diets (Min *et a.,* 2003). In the forages studied to date in NZ, CT in the legume *Lotus corniculatus* (25 – 40 g/kg DM) has been the most effective for increasing EAA absorption (Waghorn *et a.,* 1987; Barry & McNabb, 1999; Min *et a.,* 2003).

FIELD EXPERIMENTS WITH *LOTUS CORNICULATUS*

In a range of field experiments conducted in NZ over the past 12 years, grazing ruminants on *L. corniculatus* has been associated with increases in wool production (15%; Min *et al.,* 1998), milk production (20-40%; Wang *et al.,* 1996; Woodward *et al.,* 1999) and ovulation rate (20–30%; Min *et al.,* 1999, 2001), relative to control sheep grazed on perennial ryegrass / white clover pasture, with generally at least 50% of these increases due to the action of its CT. The increases in ovulation rate were associated with increases in plasma concentration of total EAA and branched chain amino acids (BCAA; Table 1), with PEG drenching studies showing that most of this could be attributed to CT.

In a systems approach conducted at Riverside farm in the Wairarapa, feeding *L. corniculatus* for 9 weeks during mating increased scanning and lambing percentages relative to control ewes mated on grass-based pastures (Table 2; 95 ewes/group) as expected, but also substantially reduced post-natal lamb mortality. These results were achieved despite the absence of effects upon lamb birth weight or lamb weaning weight. In a follow-up study using groups of 75 ewes, grazing on *L. corniculatus* for 0, 10, 21 and 42 days before synchronised mating linearly increased ovulation rate from 173 to 200% (P<0.05) and tended to reduce post-natal lamb mortality from 24.1 to 19.5%, but the linear trend failed to reach statistical significance (P>0.05; Ramirez-Restrepo., 2004, Ramirez-Restrepo *et al.,* 2004).

SUPPLEMENTING EWES GRAZING DROUGHT PASTURES WITH WILLOW AND POPLAR

Willow and poplar are also being used by farmers as a supplement during mating to ewes grazing drought pastures (Charlton *et al.,* 2003). Willow is eaten by sheep to a diameter of approximately 4 mm and poplar to a diameter of approximately 6 mm; diet selected under these conditions contains 7-19 and 27-52 g CT/kg DM for poplar and willow respectively and is relatively high in protein (170 g/kg DM; McWilliam *et al.,* 2004 a,b). In three controlled field trials, supplementation of ewes grazing drought pasture with 1.4 kg of fresh willow or poplar per day during mating reduced weight loss in all three years (100 ewes/group) and substantially increased scanning and lambing percentages in the first two years (Table 3). In the third year, willow supplementation did not increase scanning and lambing percentage, due to high zearalenone concentration in the drought pasture (1-2 mg/kg DM), but it did reduce post-natal lamb mortality (P<0.05). A similar trend was evident in the second year, but did not attain statistical significance (P>0.05). Willow and poplar supplementation under these conditions would be expected to increase EAA absorption; thus, as in the situation when mating on *L. corniculatus*, supplementing with willow and poplar during mating may also be associated with reduced lamb losses between birth and weaning.

TABLE 1: The effect of condensed tannins in Lotus corniculatus upon plasma concentration of essential amino acids (EAA) and branched chain amino acids (BCAA; µm) in ewes grazing perennial ryegrass/white clover pasture and the legume *L. corniculatus* during mating

	Pasture		***Lotus***		**SEM**
	PEG [1] Sheep	CT acting Sheep	PEG [1] Sheep	CT acting Sheep	
Total EAA	786	742	894	1128	35.9
Total BCAA	267	241	312	379	12.8
Valine	138	126	161	199	5.2
Leucine	77	69	93	108	3.8
Iso-Leucine	52	45	58	72	3.3

From Min *et al* (1999).
[1] Polyethylene glycol (MW 3,350), which specifically binds and inactivates forage CT.

TABLE 2: The effect of mating ewes (95/group) on perennial ryegrass/white clover pasture and on the legume *Lotus corniculatus* upon reproductive performance and lamb mortality between birth and weaning.

	Pasture	***Lotus***	**SEM**
Liveweight change (g/d)	-5	67	***
Scanning (foetus/100 ewes mated)	170	179	*
Lambing (lambs/100 ewes lambing)	159	175	*
Weaning (lambs/100 ewes lambing)	123	55	*
Post-natal mortality (%)	22.9	11.7	*
Lamb birth weight (kg)			
Single – Male	6.43	6.38	NS
- Female	5.94	5.91	NS
Multiple – Male	4.93	5.06	NS
- Female	4.59	4.60	NS

From Ramirez-Restrepo *et al* (2004); lotus was grazed for 63 days, including two cycles of mating.

TABLE 3: The effect of supplementing ewes (100/group) grazing low quality drought pasture with willow / poplar during mating upon reproductive performance (lambs/100 ewes mated) and lamb mortality between birth and weaning.

	Control	Willow or poplar-supplemented	SEM
(Experiment 1; poplar supplementation)			
Liveweight change (g/d)	-82	-67	5.2
Scanning	122	163	5.7
Lambing	121	155	5.8
Weaning	96	125	6.4
Post-natal mortality (%)	20.9	19.4	3.5
(Experiment 2; willow supplementation)			
Liveweight change (g/d)	-103	-86	4.3
Scanning	132	148	6.8
Lambing	131	148	6.9
Weaning	106	126	7.4
Post-natal mortality (%)	19.5	15.0	3.4
(Experiment 3; willow supplementation)			
Liveweight change (g/d)	-147	-96	4.5
Scanning	128	128	5.6
Lambing	124	127	5.6
Weaning	103	116	5.6
Post-natal mortality (%)	17.1	8.4	3.0

From McWilliam *et al* (2004 a, b) and McWilliam (2004); all supplements fed for approximately 70 days including two cycles of mating.

Note: Supplements fed for 71 days in 2001, 87 days in 2002 and 63 days in 2003.

Feeding strategies which increase EAA absorption during mating therefore seem to consistently increase ovulation rate and lambing percentages and to reduce post-natal lamb mortality under some but not all conditions. To investigate reasons for the latter, group sizes were calculated that would have a 95% probability of detecting reductions in lamb mortality (Table 4). These show that in excess of 300 ewes/treatment are needed in order to have a reasonable probability of detecting differences in lamb mortality between nutritional treatments as statistically significant, much more than the 100 ewes group that are necessary for studies in ovulation and lambing percentage. (Ramirez-Restrepo 2004, Ramirez-Restrepo *et al* 2004).

TABLE 4: Ewes needed to detect reductions in lamb mortality at the 5% level of significance.

Reduction in post-natal lamb mortality[1] (%)	Ewes needed per group	
	Experiment 1	**Experiment 2**
20	698	665
30	296	282
40	158	151
0	95	91

[1] Assumed to be 23% mortality in lambs from control ewes.
Adapted from Ramirez-Restrepo *et al* (2004).

MECHANISMS OF ACTION

The mechanisms by which CT exerts its effects upon pre- and post-natal lamb survival remain to be elucidated. Nonetheless, given that the main nutritional effects of CT is to increase the availability of EAA, particularly BCAA, we postulate that its effects depend upon their creating a supply of amino acids that are better able than pasture-derived protein to support early embryonic development. This, in turn, might be expected to improve rates of development of the embryo/foetus and its placental attachments, with later, long-term consequences upon the foetus'/neonate's carbohydrate and protein metabolism. Additionally, where the period of 'ideal protein' availability also spans the period of organogenesis and development of the haemopoietic and immune systems, it may also affect these. How long these effects of improved protein nutrition persist through the animals' lives also remains unknown: longevity and/or survival studies would therefore be of considerable interest as well.

Nevertheless, by whatever means the response to CT is effected, it is clear that it behaves as a permanent/long-term non-genetic response to the maternal environment that is present in the very early post-mating period of gestation (or, possibly, even in the period when final selection and maturation of the follicles that give rise to these embryos is taking place). The challenge that is presented by the aforegoing studies is, therefore, to identify the critical points at which improved protein nutrition affects the reproductive system (i.e. to affect lamb survival). Management and nutritional strategies can then be developed that include the use of CT-containing plants and also other methods of increasing the supply of EAA and BCAA to grazing ewes over the critical time period.

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