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The effect of grazing ewe lambs on lucerne (*Medicago sativa*) prior to breeding on aspects of reproductive performance

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Abstract

Ewe lamb breeding can result in low and variable reproductive performance which is one of the reasons given by farmers for not breeding their ewe lambs. Ewe lamb twinning rates are known to be increased with greater ewe liveweight gain in the weeks leading up to the introduction of the ram. The hypothesis was that offering lucerne for a one-month period that ended 14 days prior to breeding would alter the pattern of breeding (i.e. cycle of conception) and pregnancy and reproductive rates of ewe lambs. Offering lucerne had no effect ($P>0.05$) on the pattern of breeding in both years of the study, respectively. Offering lucerne, however, resulted in a greater percentage of ewe lambs diagnosed with twin-fetuses compared to those offered unimproved ryegrass pastures in 2015 (35% vs. 18%, respectively). In 2016, however, there was no effect of grazing lucerne on reproductive rate. The difference between years was likely the result of lower lucerne masses offered in 2015 than in 2016.

Keywords: ewe lambs; body condition score; reproduction; lucerne; clover

Introduction

Breeding ewe lambs at six to eight months of age is a management tool that can increase farm productivity (Dyrmundsson 1973; Kenyon et al. 2014). Breeding ewe lambs at this age provides a number of advantages including a greater number of lambs born in the entire flock, greater life-time productivity of the ewe, a shorter generation interval and greater potential genetic gain from a greater number of lambs from which to choose replacement animals (Dyrmundsson 1973; Kenyon et al. 2014). Compared with mature ewes, however, breeding ewe lambs can result in low and variable reproductive rates (Hight 1982; Kenyon et al. 2004). In addition, ewe lambs, compared to mature ewes, show shorter and weaker oestrus and poorer breeding behaviours such as seeking out the ram (Dyrmundsson 1981; Hight & Jury 1976). Ewe lambs have also been shown to have lower rates of ovulation, conception and embryonic survival than mature ewes (Dyrmundsson 1981; Annett and Carson 2006; Mulvaney et al. 2013). In order to become pregnant, ewe lambs need to first attain puberty and begin to display oestrus (Kenyon et al. 2014). The onset of puberty is influenced by decreasing day length and ewe lamb live weight (Dyrmundsson 1981). Ewe lambs generally attain puberty when they reach 40% to 70% of their mature live weight (Dyrmundsson 1981). Live weight can have both a 'static' and a 'dynamic' effect on the onset of puberty. The 'static' effect is that heavier ewe lambs are more likely to attain their first oestrus than lighter ewes (Smith 1991). The 'dynamic' effect refers to ewe liveweight gain such that at a given live weight, ewe lambs with greater rates of gain have an greater chance of attaining puberty compared to a slower-growing ewe lamb (McMillan & Moore 1983). The influence of live weight on ovulation rate of mature ewes has received a great deal of attention, however, less is known about the response of ewe

lambs, although a small number of studies have reported that increases in ewe-lamb live weight increased ovulation rate (Scaramuzzi et al. 2006; Smith 1991).

The use of alternative forages to ryegrass pasture has been investigated as a means to increase the productivity of sheep in a number of different ways. Forages such as lucerne (*Medicago sativa*) or clover (*Trifolium* species) swards and mixes containing clovers have been used to increase growth rates of lambs both before and after weaning, increase the milk production of ewes bearing multiple fetuses, and as a method to allow for the early weaning of lambs (Cranston et al. 2015; Moot 2012). Lucerne can contain the phytoestrogen, coumestrol, at levels between 0 and 200 ppm (Scales et al., 1977). Coumestrol concentrations greater than 100 ppm can result in depressed reproductive performance through the production of endogenous oestrogen (Kelly et al., 1976; Scales et al., 1977; Smith et al. 1979). It has been suggested that any negative effects of phyto-oestrogens can be negated by a short period (approximately 3 weeks) of grazing ryegrass pastures prior to breeding (McGaveston 2012), hence, the impact of offering lucerne on measures of ewe lamb reproductive performance was compared against pasture. The hypothesis was that ewe lambs offered lucerne in the month prior to breeding would have greater liveweight gains and, therefore, greater fertility and reproductive rates than ewes offered pasture.

Materials and methods

In autumn of 2015 and 2016, studies were conducted at Massey University's Riverside farm in the Wairarapa region of New Zealand (40°50'S, 175°38'E). The studies were conducted with the approval of the Massey University Animal Ethics Committee.

Animal measurements

Study design 2015

Romney ewe lambs ($n=200$) ranging in live weight from 33 to 48 kg were selected for inclusion in the study. Ewe lambs were allocated to one of two treatment groups: old ryegrass white clover pasture sown more than five years previously (Pasture; $n=100$) or a pure lucerne sward (Lucerne; $n=100$). The allocation was conducted using a stratified random method which resulted in the two treatments having similar live weights and body condition scores (BCS) at the start of the feeding period (Pasture 37.4 ± 0.2 kg and 3.0 ± 0.03 BCS versus Lucerne 37.3 ± 0.2 kg and 3.1 ± 0.03 BCS). Ewes were offered their respective treatment for 30 days beginning 42 days prior to the start of breeding (day -42 of pregnancy or P-42; 31 March 2015). During the feeding period ewe lambs were rotationally grazed with the intention of maintaining a minimum herbage mass in the Pasture treatment of 1200 kgDM/ha and sward surface height in the Lucerne treatment of 10 cm. On P-17, vasectomised rams were introduced to the ewe-lamb flock at a ratio of 1:100. On day P-11, ewes were removed from their respective feeding treatments and were managed as a single mob on ryegrass white clover pastures for the remainder of the study. At P1, ewe lambs were weighed and condition scored. Ewe lambs that weighed 40 kg or more were retained and bred ($n=199$). One ewe in the Pasture treatment failed to achieve the minimum live weight (40 kg) and was removed from the study. On P1 the vasectomised rams were removed from the ewe-lamb flock and replaced with entire rams fitted with breeding harnesses. On P17, the breeding harness crayon colour was changed to allow the identification of ewes that were marked in the first, second or both first and second 17-day oestrous cycles of the breeding period. The entire rams were removed from the breeding flock on P34 and records were made of ewes that had ram harness marks. The ewes were managed as a single group under commercial farming conditions on ryegrass pastures until pregnancy diagnosis (P90). Pregnancy diagnosis was undertaken by an experienced operator using trans-abdominal ultrasound. The pregnancy status (not pregnant or pregnant) and number of fetuses (0, 1, 2 or 3) was recorded for each ewe. Ewes were weighed and their BCS recorded on days P-42, P-11, P1 and P90.

Study design 2016

The study design in 2016 was similar to that of the previous year, however, there were some variations. Ewe lambs ($n=200$) ranging in live weight from 34.5 to 50 kg, were randomly allocated on the 24th March 2016 (P-38) to either the Pasture ($n=100$) or Lucerne ($n=100$) treatments using a stratified random allocation (Pasture 37.3 ± 0.3 kg and 2.8 ± 0.04 BCS versus Lucerne 37.9 ± 0.3 kg and 2.7 ± 0.04 BCS). The ewe lambs were offered their respective feeding treatments from P-38 until P-12 at which time the ewes were managed as a single flock on a ryegrass pasture. During the feeding period ewes were rotationally grazed. Due to

the very dry weather conditions, however, the minimum targets set for the Pasture treatment were reduced to 1000 kgDM/ha and for the Lucerne treatment sward surface heights to 2 cm. As in 2015, teaser rams were introduced to the ewe flock on P-17 and removed on P1 and entire rams were utilised for 34 days from P1 to P34. Ewe lambs that weighed more than 40 kg at P1 ($n=195$) were retained in the breeding flock. Two ewes in the Pasture treatment and three in Lucerne failed to achieve the minimum live weight and were removed from the study. On P95 pregnancy diagnosis was conducted. Ewe lambs were weighed and their BCS recorded on P-38, P-16, P1 and P95.

Herbage measurements

Herbage mass (HM) of the Pasture and Lucerne treatments was measured using the quadrat cut (0.1m^2) method described by Frame (1993). In short, herbage cuts ($n=4$ per treatment) were taken to ground level within a metal frame measuring 20 x 50 cm. Collected samples were then washed to remove any soil and then placed in 70°C oven for a minimum of 48 hours (Staff 1961). Herbage masses were calculated from the average of the dried quadrat sample masses. Herbage masses were recorded on days -42, P-11 and P1 in 2015 and P-38 and P-16 in 2016. In addition, a botanical composition was determined on each of the sampling days by collecting four samples comprised of 10 random herbage grab samples per treatment. From these samples a sub-sample (~20 g of pasture and ~40 g of lucerne) was removed and sorted. The pasture samples were sorted into ryegrass, other grasses, white clover, red clover, weeds and dead material. Lucerne samples were sorted into lucerne, white clover, red clover, grasses, weeds and dead material. The sorted samples were then dried in an oven at 70°C for a minimum of 48 hours. Once dried each of the components of the sorted sample were weighed to determine the percentage of each component.

Statistical analysis

Statistical analyses were conducted using SAS 9.4 (SAS Institute Inc, 2012, Cary, NC, USA). For all outcome variables analyses were conducted for each year separately due to differences in the length of feeding periods.

Herbage measures

Herbage mass and botanical composition at each sampling were summarised by feeding treatment using descriptive statistics (mean and standard error of the mean).

Live weight and Body condition score

Ewe lamb live weight was analysed using a general linear model (Proc Mixed) which included the fixed effect of treatment (Pasture and Lucerne). Ewe lamb BCS was analysed using a generalised linear model (Proc Genmod) using a Poisson distribution and a logit transformation and included the fixed effect of treatment.

Pattern of breeding

Ram-harness marks were not recorded for two ewe lambs in 2015 (Pasture $n=1$ and Lucerne $n=1$) and five

ewes in 2016 (Pasture n=2 and Lucerne n=3). The pattern of breeding, as indicated by ram-harness marks (presence or absence of harness marks at P17 and P34, in both 2015 and 2016) was analysed using a generalised linear model (Proc Genmod). The model contained the fixed effect of treatment and used a binomial distribution and a logit transformation.

Pregnancy diagnosis

Pregnancy diagnosis results were not recorded for one ewe lamb in 2015 (Pasture n=1) and six ewes in 2016 (Pasture n=2 and Lucerne n=4). No ewes were identified as bearing triplet foetuses in either 2015 or 2016, therefore, analyses relating to triplets were not conducted. Fertility rate (not pregnant vs. pregnant) was analysed using a generalised linear model (Proc Genmod) using a binomial distribution and the fixed effect of ewe treatment. Results are presented as the number of ewes identified as pregnant per 100 ewes presented for breeding (back-transformed means with 95% confidence interval in parentheses). Reproductive rate (0, 1, or 2 fetuses) was analysed using a generalised linear model (Proc Genmod) using a Poisson distribution and a logit transformation with the fixed effect of treatment. Results are presented as the number of fetuses identified per 100 ewes presented for breeding (back-transformed means with 95% confidence interval in parentheses).

Results

Herbage measures + nutritional analysis

2015 Study

During the feeding period the herbage masses of the Pasture treatment were in excess of 3000 kgDM/ha (Table 1). The herbage mass in the Lucerne treatment began at less than 2000 kgDM/ha but increased during the feeding period to masses in excess of 3500kgDM/ha. The ME content of both Pasture and Lucerne decreased during the feeding period

In the Pasture treatment, the percentage of grasses decreased and the percentage of dead material increased during the feeding period (P<0.05; Table 1). The Pasture contained less than 3% clover throughout the feeding period. The percentage of Lucerne decreased during the

feeding period due to an increase in the percentage of dead material (P<0.05).

2016 Study

At the start of the feeding period (P-38) Pasture had a herbage mass of 1707±157 kg DM/ha and ME of 8.0±0.2 MJ/kgDM and the Lucerne mass was 1446±257 kg DM/ha and had a ME of 9.0±0.2 MJ/kgDM. At the end of the feeding period (P-16) Pasture herbage mass was 1143±201 kg DM/ha and had a ME of 8.3±0.2 MJ/kgDM whereas Lucerne mass was 880±37 kg DM/ha and had an ME of 7.5±0.2 MJ/kgDM.

In 2016, the proportion of grasses (ryegrass plus other grass) in the Pasture increased and percentage of dead material decreased during the feeding treatment (P<0.05; Table 1). The clover content of the Pasture also increased during the feeding period (P<0.05). As in 2015, the percentage of Lucerne decreased dramatically during the feeding period due to an increase in dead material (P<0.05).

Ewe lamb live weight and body condition

2015 study

At P-42 the live weight of ewe lambs in the Pasture and Lucerne treatments did not differ (P>0.05) but at P-11, P1 and P90 ewes lambs in the Lucerne treatment were heavier than those in the Pasture treatment (P<0.05; Table 2). During the feeding period (P-42 to P-12) ewe lambs offered Lucerne grew more quickly (P<0.05) than ewes offered Pasture (197±6 g/day vs. 148±6 g/day, respectively). Ewe-lamb body-condition scores did not differ between treatment groups throughout the study (P>0.05, data not shown).

2016 study

At P-38, the live weight of ewe lambs in the Pasture and Lucerne treatments did not differ (P>0.05) but at P-16, ewes in the Pasture treatment were heavier than those on Lucerne (P<0.05). During the feeding period (P-38 to P-16) ewe lambs offered Pasture treatment grew more quickly (P<0.05) than did ewes offered Lucerne (176±9 vs. 56±9 g/day, respectively). At P1 and P95 differences in ewe lamb live weight were no longer observed (P>0.05). Ewe-lamb body-condition scores did not differ throughout the study (P>0.05; data not shown).

Table 1 The herbage mass, metabolisable energy (ME), protein and digestibility (DOMD) of Pasture and Lucerne at P-42, P-26 and P-11 in 2015 and P-38 and P-16 in 2016 reported as the percentage ± SEM

Treatment		2015			2016	
		P-42	P-26	P-11	P-38	P-16
Pasture	Herbage mass (kgDM/ha)	3193±740	3038±451	4131±142	1707±157	1143±201
	ME (MJ/kgDM)	9.4±0.2	8.8±0.2	8.3±0.2	8.0±0.2	8.3±0.2
	Protein (%)	16.1±1.0	12.1±1.0	14.1±1.0	9.8±1.0	15.6±1.0
	DOMD (%)	58.8±1.2	54.9±1.2	52.0±1.2	49.9±1.2	52.2±1.2
Lucerne	Herbage mass (kgDM/ha)	1848±332	4412±738	3805±615	1446±257	880±37
	ME (MJ/kgDM)	10.3±0.2	7.9±0.2	8.0±0.2	9.0±0.2	7.5±0.2
	Protein (%)	20.3±1.0	12.1±1.0	13.0±1.0	16.6±1.0	11.3±1.0
	DOMD (%)	64.3±1.2	49.2±1.2	49.7±1.4	56.3±1.2	46.7±1.2

Table 2 The botanical composition of Pasture and Lucerne at P-42, P-26 and P-11 in 2015 and P-38 and P-16 in 2016 reported as the percentage \pm SEM.

Treatment		2015			2016	
		P-42	P-26	P-11	P-38	P-16
Pasture	Ryegrass (%)	31.0 \pm 5.2	29.6 \pm 5.2	26.0 \pm 5.2	11.3 \pm 2.7 ^a	47.8 \pm 2.7 ^b
	Other grasses (%)	56.4 \pm 6.7	47.6 \pm 6.7	49.7 \pm 6.7	20.6 \pm 1.4 ^b	0.6 \pm 1.4 ^a
	White clover (%)	2.1 \pm 0.5	0.7 \pm 0.5	0.7 \pm 0.5	0.8 \pm 0.7 ^a	4.1 \pm 0.7 ^b
	Weeds (%)	0.2 \pm 1.3	0.7 \pm 1.3	3.3 \pm 1.3	0.5 \pm 0.2	-
	Dead (%)*	10.4 \pm 3.7 ^a	21.4 \pm 3.7 ^b	20.3 \pm 3.7 ^b	66.9 \pm 2.6 ^b	47.5 \pm 2.6 ^a
Lucerne	Lucerne (%)	93.5 \pm 4.2 ^b	36.3 \pm 4.2 ^a	28.0 \pm 4.2 ^a	81.5 \pm 4.3 ^b	27.6 \pm 4.3 ^a
	White clover (%)	-	0.8 \pm 0.5	0.4 \pm 0.5	-	-
	Red clover (%)	-	-	-	-	-
	Weeds (%)	0.8 \pm 0.2	-	-	-	-
	Dead (%)*	5.7 \pm 4.1 ^a	62.7 \pm 4.1 ^b	71.5 \pm 4.1 ^b	18.5 \pm 4.3 ^a	72.4 \pm 4.3 ^b

Superscripts with different letters are significantly different ($P < 0.05$).

* Dead material irrespective of plant origin

Table 3 Effect of feeding treatment (Pasture or Lucerne) on ewe lamb live weight (mean \pm SEM) of on days -42, -11, 1 and 90 relative to start of breeding in 2015 and days -38, -16, 1 and 90 in 2016.

Treatment	Ewe lamb live weight (kg)							
	n	P-42	n	P-11	n	P1	n	P90
2015								
Lucerne	100	37.9 \pm 0.2	100	44.1 \pm 0.2 ^b	100	50.9 \pm 0.3 ^b	100	51.1 \pm 0.4 ^b
Pasture	100	38.1 \pm 0.2	100	42.7 \pm 0.2 ^a	100	49.1 \pm 0.3 ^a	100	48.3 \pm 0.4 ^a
2016								
	n	P-38	n	P-16	n	P1	n	P95
Lucerne	100	37.9 \pm 0.3	100	39.0 \pm 0.3 ^a	100	42.4 \pm 0.3	94	46.5 \pm 0.3
Pasture	100	37.4 \pm 0.3	100	41.6 \pm 0.3 ^b	100	42.0 \pm 0.3	93	46.3 \pm 0.3

Superscripts with different letters are significantly different ($P < 0.05$)

Pattern of breeding 2015 and 2016 studies

The percentage of ewe lambs marked in the first cycle only, second cycle only, that returned to service, or that were not marked during the breeding period, did not differ between treatments in either year of the study ($P > 0.05$; data not shown).

Pregnancy diagnosis 2015 study

The percentage of ewe lambs that were identified as not pregnant or single-bearing did not differ between the treatments ($P > 0.05$; Table 3). In the Lucerne treatment, however, a greater percentage of ewe lambs were identified with twin fetuses compared to Pasture ($P < 0.05$). The reproductive rate of ewes in the Lucerne treatment tended ($P = 0.09$) to be greater than for ewe lambs offered Pasture (back-transformed mean 108, 95% confidence interval 89.4 – 130.4) vs. 98.9 (80.6 – 121.4) foetuses per 100 ewes presented for breeding, respectively).

2016 study

The percentage of ewe lambs that were diagnosed as not pregnant or bearing a single or twin fetuses did not differ between the Pasture and Lucerne treatments ($P > 0.05$; Table 3) nor did the overall reproductive rate (back-transformed

mean 91.4, 95% confidence interval 73.9 – 113.1 vs. 96.8, 78.8 – 118.9, respectively).

Discussion

The aim of these studies was to determine the impact of offering ewe lambs lucerne during the month prior to breeding, while allowing for a short period off lucerne, on ewe lamb live weight, liveweight gain, the pattern of breeding and fertility and reproductive rates. In both 2015 and 2016, feeding treatments resulted in differences in the live weight of ewe lambs at the end of the feeding period but these varied between years with low live weight gains observed the Lucerne treatment in 2016.

Ewe lambs offered the lucerne in 2015 were heavier at the end of the feeding period than ewes in the pasture treatment. This result is in agreement with a number of previous studies which show increased liveweight gains of weaned lambs (3 to 9 months of age) when grazing lucerne compared to ryegrass pastures (Burke et al. 2002; Jagusch et al. 1981; Scales et al. 1995). In 2016, however, ewe lambs offered lucerne were lighter at the end of the feeding period compared to those offered pasture. This is likely due to the lucerne treatment having very low DM levels (< 900 kg DM/ha) during the feeding period in that year which is likely to have reduced ewe lamb intake. Indeed the

Table 4 Effect of feeding treatment (Pasture or Lucerne) on the percentage (back-transformed mean with 95% confidence interval in parentheses) of ewe lambs that were diagnosed as non-pregnant, or bearing single or twin fetuses at pregnancy diagnosis at P90 in 2015 and P95 in 2016.

	2015			
	n	Single-bearing	Twin-bearing	Not pregnant
Lucerne	100	38 (29–48)	35 (26–45) ^b	27 (19–37)
Pasture	99	48 (39–58)	18 (12–27) ^a	33 (25–43)
<hr/>				
	2016			
	n	Single-bearing	Twin-bearing	Not pregnant
Lucerne	93	54 (44–64)	21 (14–31)	24 (17–34)
Pasture	94	59 (49–69)	16 (10–25)	24 (17–34)

Superscripts with different letters are significantly different ($P < 0.05$)

composition and quality analysis of the lucerne indicated that the lucerne offered was of poor quality. These results indicate that poor lucerne should be avoided if the intention is for ewes to gain weight prior to breeding.

Feeding treatment had no effect on the pattern of ewe-lamb breeding in the current study. This lack of an effect may be somewhat surprising given that the onset of puberty in sheep is known to be controlled by a combination of ewe live weight and declining day length (Dyrmundsson 1981; Kenyon et al 2014). The reason for the lack of difference is not clear as the difference in live weight at the start of breeding between treatments was 1.8 kg. Previously, Kenyon et al. (2006) reported differences in live weight of 2.0 and 1.9 kg between ewes that were bred in the first cycle compared with those bred in either the second cycle only, or not at all, respectively.

Offering ewe lambs lucerne resulted in a greater proportion of ewes that conceived twin-fetuses compared with ewes offered grass pastures in 2015, but not 2016. Previously, it has been reported ewe lambs offered pasture that were diagnosed as twin-bearing were between 1.1 and 1.8 kg heavier at breeding than their single-bearing counterparts (Kenyon et al. 2006; Kenyon et al. 2005; Kenyon et al. 2010). The lack of a difference in ewe-lamb live weight at breeding in 2016, together with the lack of difference in the percentage of ewe lambs with single and twin fetuses is consistent with this finding. It appears that the gains in pregnancy rate achieved by offering lucerne are the result of the ewe lambs being heavier than those offered pasture.

Generally, it is recommended that ewes should not be offered lucerne before breeding due to the negative effects of coumestrol, a phyto-oestrogen present in lucerne (McGaveston 2012). Jagusch et al (1980) reported that when coumestrol concentrations were low, mature ewes grazing on lucerne prior to breeding had greater ovulation rates compared with ewes grazing ryegrass pastures. Recently, a series of studies from Australia reported that short-term grazing of lucerne compared with senescent pasture or phalaris (seven and nine days pre-breeding) resulted in greater ovulation rates (King et al. 2010;

Robertson et al. 2015). There is little information available, however, on the effect of offering lucerne to ewe lambs during breeding. The results of the present study showed that there were no negative effects of offering lucerne prior to breeding on the number of fetuses identified. Phyto-oestrogen concentrations, however, were not measured in this study so no conclusion can be made regarding whether the 12-day washout period had any influence on the effects of coumestans.

To the knowledge of these authors there is only a single study that has compared the growth and reproduction of ewe lambs offered a range of forages, including lucerne, four-weeks prior to breeding and throughout the six-week breeding period. They reported that ewe lambs that grazed lucerne, compared with ewe lambs offered pasture and supplemented with pellets, had higher pregnancy rates (96 vs. 85%) and reproductive rates (151 vs. 103 lambs per 100 ewes presented for breeding) (Raeside et al. 2015). In that study, ewe lambs offered lucerne were 2.3 kg heavier at the end of the breeding period compared to those offered pasture+pellets, but had similar live weights at the start of the breeding period. Combined, these studies suggest that offering ewe lambs sufficient quality and quantity of lucerne, either prior to, or during the breeding period can improve pregnancy and reproductive rates.

Conclusion

Ewe-lamb reproduction can be improved by offering lucerne for one month prior to breeding if herbage masses offered result in increased liveweight gains compared with those offered old pasture. Care must be taken, however, to ensure there is a period off lucerne prior to breeding to negate any potential negative effect of phyto-oestrogens.

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