Final Report

Alternative Forages for Pregnant and Lactating Ewes

Summary sheet

An experiment was conducted to investigate the effect of forage type on ewe and lamb performance. Forty eight twin bearing Suffolk cross Mule ewes (average liveweight of 75 kg) at 8 weeks pre-lambing were allocated to one of four high protein forages: grass silage (GS), Lucerne silage (LS) red clover silage (RC) or urea treated whole crop wheat (UTWC). Ewes were individually penned from 6 weeks prior to lambing until 4 weeks post lambing. At week – 6 UTWC was mixed on a 50:50 dry matter basis with grass silage due to ewes selecting out whole grains when in group pens. Ewes were supplemented with sugar beet pulp and barley according to forage intake and fed according to AFRC 1993 metabolisable energy and protein requirements. Dry matter intake of forages varied throughout the trial but intake of RC was significantly higher ($P<0.001$) than all other forages until week +2 when intakes of all other silages increased. Intake of GS was consistently lower than all other silages from week -5 to week -2. RC fed ewes tended to maintain body condition better than ewes on the other forages and were in significantly better condition at lambing ($P<0.01$) than GS or UTWC/GS fed ewes. Plasma urea was significantly higher for LS fed ewes suggesting a surplus of ERDP in the diet. Lamb birth weights tended to be higher for GS fed lambs (NS) and lowest for RC lambs but thereafter lambs from RC fed ewes tended to grow faster (NS) than lambs from ewes on the other three forages.

High protein forages can be fed without additional protein supplementation to save on purchased feed costs but the particularly high dry matter intake of RC silage in this trial suggested a greater requirement for forage that needs to be taken in to account when costing out rations for pregnant and lactating ewes.

Project number			
Start date	January 2016	**End date**	October 2017
Project aim and objectives			
To investigate the effects of four different high protein forages on ewe performance in late pregnancy and early lactation and subsequent effects on lamb birth weight and growth to weaning. To compare red clover, lucerne, urea-treated whole crop wheat and grass silages for feeding pregnancy and lactating ewes.			
Lead partner	Harper Adams University		
Scientific partners			
Industry partners	GLW Feeds Ltd		
Government sponsor			

Has your project featured in any of the following?

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Events ***AHDB Sheep Research day at Harper Adams 10/7/16*** ***AHDB Research day 13/9/16***	***Press articles***
Conference presentations, papers or posters	***Scientific papers***
Other	

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Alternative Forages for Pregnant and Lactating Ewes

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Funded by AHDB Beef & Lamb

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Summary
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1.0 Introduction

A large volume of grass produced on farms is wasted due to poor grassland management, and recent efforts by AHDB and others to focus the minds of sheep producers on improving production from forage alone should help to reduce the costs of production and dependence on purchased feeds. The profitability of sheep farming is precarious, and every attempt needs to be made to reduce the costs of production and improve efficiency.

High protein forages, now more commonly grown in the UK, such as red clover or Lucerne offer one potential solution – producing high quality silage for winter feeding and aftermath grazing for finishing lambs. Likewise whole crop wheat offers certain advantages when considered as part of a whole farm approach for mixed farms (recent 3 crop rule for the basic payment scheme). Urea treated whole crop wheat (Alkalage) has high energy (11.0 MJ/kg DM) and relatively high protein (170 g/kg DM) and is more comparable to high quality legume silages than fermented whole crop.

Current standards for dry matter intake prediction in sheep (AFRC, 1993) often underestimate actual dry matter intake in practice on modern, high quality forages fed to today's genetically superior animals (Cottrill, 2001, Robinson, 2001). There are also concerns that current nutritional standards may not be appropriate in some situations and that ME and MP requirements may need to be reviewed and updated. There is therefore a need to provide better guidance to nutritionists, vets and farmers to provide ewes with diets that more closely meet their nutritional demands in late pregnancy and lactation leading to optimum lamb performance.

Feed represents approximately 60% of the variable costs of lowland sheep production (Stocktake, 2015) with purchased concentrates amounting to over 60% of total feed costs. The cost of purchased feed (@ £2.50/kg DM) far exceeds that of home grown forages (e.g. grass silage @£1.20/kg DM). If high quality forages, delivering good supplies of energy and protein, can be grown reliably, requiring minimal supplementary feed for pregnant ewes, concentrate feed costs could be cut dramatically, helping to increase profitability. Heavy use of concentrate feeds has the potential to cause rumen acidosis and other associated metabolic problems and a predominantly forage based diet is far more desirable from a nutritional and health perspective. There are very substantial differences in financial performance between the most efficient and least efficient sheep flocks (AHDB Stocktake results for 2015). With the potential to make huge savings on feed costs and improve flock performance, more producers need to embrace opportunities for reducing the cost of production. Greater or improved use of alternative forages could offer an effective solution.

2.0 Objective

To investigate the effects of four different high protein forages on ewe performance in late pregnancy and early lactation and subsequent effects on lamb birth weight and growth to weaning.

3.0 Materials and methods

3.1 Experimental design

Forty eight twin-bearing ewes (Suffolk x North of England Mules) with a mean liveweight (LW) of 75 kg from the Harper Adams University flock were housed and allocated by parity, LW and condition score (CS) on day 90 of gestation into four groups. They were fed one of four forages *ad libitum* for 2 weeks to acclimatise to their new diet (straw was also available *ad-libitum*). All the ewes were housed individually and bedded on sawdust from day 105 of gestation (week -6) and fed their allocated forage *ad-libitum* until day 119 when sugar beet pulp was offered according to energy intake from forage to meet ME and MP requirements (AFRC, 1993). On day 138 barley was introduced to help meet ME and MP requirements according to forage intake (see Table 1.)The trial was a randomised block design including the following forages:

1. Grass silage (GS)
2. Lucerne (LS)
3. Red clover/perennial ryegrass (RC)
4. Urea treated whole crop wheat (UTWC)

All ewes were also offered 25g of a general purpose sheep mineral each day throughout the housing period.

The diets were formulated to supply similar levels of metabolisable energy (ME), and metabolisable protein (MP) to AFRC 1993 requirements.

Sugar beet pulp (SBP) and barley were fed to provide a rising plane of nutrition and to meet the ME and MP requirements of pregnant twin-bearing ewes before lambing. In lactation SBP, barley and soya bean meal were offered with *ad-libitum* forage to meet the ME and MP requirements of 75 kg ewes producing 3.0 litres of milk during lactation (see Table 2 for nutritional analysis). Concentrates were fed twice daily from week -6 to week -2 and three times daily from week -2 to week +4. Water was available *ad-libitum*. From week +4 ewes were turned out to permanent pasture (grassland under Higher Level Stewardship) with their lambs and all lambs offered creep feed.

Table 1. Supplement feeding regime

	GS	LS	RC	WC
Wk-6 **Wk-5**	Minerals: **25g**	Minerals: **25g**	Minerals : **25g**	Minerals: **25g**
Wk-4 **Wk -3**	Minerals: **25g** SBP: **0.2kg**	Minerals : **25g** SBP: 0.4kg	Minerals: **25g** SBP: 0.4kg	Minerals : **25g** SBP: **0.2 kg**
Wk-2	Minerals: **25g** SBP: 0.6kg	Minerals: **25g** SBP: **0.6kg**	Minerals: **25g** SBP: 0.4kg	Minerals: **25g** SBP: 0.**4kg**
Wk -1	Minerals: **25g** SBP: 0.35kg Barley: **0.35kg**	Minerals: **25g** SBP: 0.375kg Barley**: 0.375kg**	Minerals: **25g** SBP: 0.25kg Barley: 0.25kg	Minerals: **25g** SBP: **0.25kg** Barley: **0.25kg**
Post lambing ration **Wk +1**	Minerals: **25g** SBP: 0.7kg Barley: **0.7kg** Soya: **0.35kg**	Minerals: **25g** SBP: 0.75kg Barley: **0.75kg** Soya: **0.25kg**	Minerals: **25g** SBP: 0.65kg Barley : **0.65kg** Soya: **0.2kg**	Minerals: **25g** SBP: 0.6kg Barley: **0.6kg** Soya: **0.35kg**
Lactation ration **Wk +2** **Wk+3** **Wk +4**	Minerals: **25g** SBP: 0.5kg Barley: **0.5kg** Soya: **0.35kg**	Minerals: **25g** SBP: 0.75kg Barley: **0.75kg** Soya: **0.25kg**	Minerals: **25g** SBP: 0.65kg Barley: **0.65kg** Soya: **0.2kg**	Minerals: **25g** SBP: **0.5kg** Barley: **0.5kg** Soya: **0.35kg**

Table 2. Nutritional value of supplements (Source: The Feeds Directory - Ewing, 1997).

	Molassed Sugar beet pulp	Barley	Soya bean meal
Dry Matter	900	860	880
ME (MJ/kgDM)	12.5	13.2	12.9
Crude protein (g/kgDM)	110	123	470
ERDP(g/kgDM) (@0.05)	49	96	349
DUP (g/kgDM)(@0.05)	38	16	119

3.2 Measurements

Individual ewe forage intake was measured daily by providing an initial amount based on ewe liveweight (and the initial intakes measured in weeks 8 to 6) and increasing by 10% per day until there were refusals. Refusals were weighed back twice each week.

Ewes were weighed and condition scored weekly by the same (competent) person at a fixed time relative to feeding. In addition, ewes were ultra-sound scanned for back-fat and eye-muscle depth at week -6, week -1, week +2, and week +4. Blood samples were obtained by venepuncture from six representative ewes on each treatment at weeks -8, -6, -3, -1, +2 and +4. Similarly, faecal grab samples were obtained from a further six representative ewes, at similar time points for the determination of faecal egg counts and eosinophil counts (eosinophils become more numerous in certain types of parasitism) on bloods were also carried out. During week -3 faecal grab samples were obtained from 6 representative animals on each treatment over a five day period to indirectly estimate diet digestibility using acid insoluble ash as an internal marker (Block *et al.,* 1981). Lamb birth weight was recorded immediately after birth and at 12h *post-partum* and LW recorded weekly to 4 weeks of age (turn out) and fortnightly thereafter to weaning.

Ultra-sound scanning to measure back fat and eye muscle depth was carried out in week -6, week -3, week -1, week +2 and week +4 by the same trained person allowing for consistent results. The BCF Digiprince DP-6900Vet and a BCF ultrasonic transducer 75L50EAV scanning probe were used to take the measurements within the weigh scales. The wool was parted at the 3rd lumbar vertebra behind the last rib and lubricating gel (liquid paraffin) applied to allow good skin contact producing high clarity images. Once a clear image was visible the screen was frozen allowing the cursor to be used to indicate the deepest muscle depth and taking a measurement and then taking three fat measurements at 1cm spacing (see plate 1).

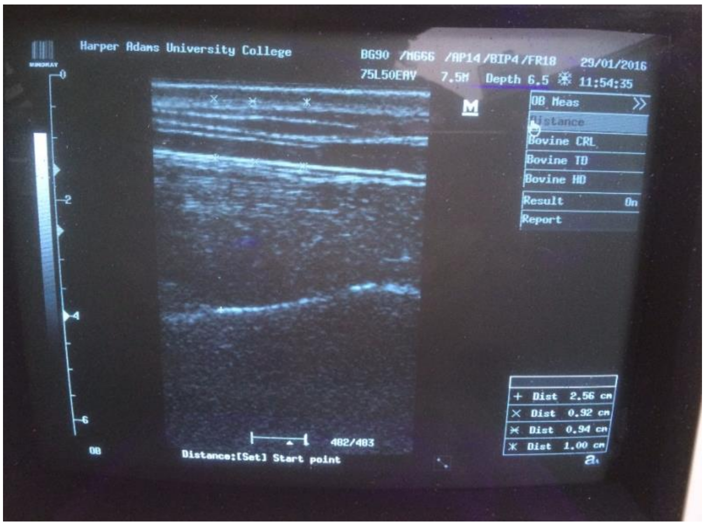


Plate 1: Ultrasound scanner screen whilst taking measurements

Both colostrum and milk yield were estimated from all ewes at 16 h and 21 days *post-partum* using a method adapted from Doney *et al*., (1979). At +12h lambs were confined behind a wire mesh barrier and ewes were injected with 1.0 ml of oxytocin (Oxytocin S 0.18 mg/ml, MSD Animal Health) to stimulate milk let down. After 2 minutes ewes were milked using an automatic milking machine (PM006, Milkingmachines.co.uk) until the udder was empty. At +16 hours *post-partum* (4 hours after initial milking) ewes were injected with a further 1.0 ml of oxytocin and the process was repeated, prior to lambs being returned to the ewe. Colostrum collected from the ewe was fed back to the lambs via stomach tube. The colostrum secretion rate was then calculated over a four hour period and extrapolated to 24 hours. The same procedure was repeated 21 days into lactation. Samples of colostrum and milk were collected and stored at -20 °C prior to further analysis.

Digestibility of the forages was assessed before concentrate feeding started. Faecal grab samples were collected from six representative animals on each diet over a period of five consecutive days during week -3. Samples were collected at the same time each day with a set routine for the animals ensuring samples were consistent. Forage samples were also collected at the same time ensuring a representative digestibility value. Acid insoluble ash was used as the internal marker to estimate digestibility (Block *et al*. 1981). Thorough mixing of the five samples took place to allow the samples to be tested as one rather than five separate samples producing six results per treatment.

3.3 Laboratory analysis

Feed and faecal samples were analysed for dry matter (DM), either extract (EE), ash and gross energy (GE) using the methods described by MAFF (1986), with crude protein (CP) being determined using the Dumas method (LECO FP-528). They were also analysed for neutral detergent fibre (NDF) and acid detergent fibre (ADF) using the methods described by Van Soest *et al*., (1991). Acid insoluble ash was determined using a method derived from Block *et al.,* (1981). Faecal egg counts were also determined using a modification of the McMasters technique (MAFF, 1979).

Following processing, blood plasma samples were analysed for glucose, beta-hydroxybutyrate (BHB), non-esterified fatty acids (NEFA), urea, albumin and total protein using a Cobas Mira Plus blood analyser (ABX Diagnostics). Similarly, milk samples were analysed for total solids (TS), fat, protein and lactose using an infra-red milk analyser (MilkoskanTM Minor, Foss Analytical), calibrated for ewes milk, with ash being determined by difference. Colostrum samples were analysed for TS, fat, ash (MAFF, 1986) and protein using the Dumas method (LECO FP-528), with lactose being calculated by difference.

3.4 Statistical analysis and calculations

The experiment was analysed by ANOVA as a randomised block design using GenStat V17, with the main effect being forage type. Regression, correlation and co-variate analysis were used where appropriate. Data on faecal egg counts was log transformed (log10 (count +1)) prior to analysis. Diet digestibility was calculated as:

$$\text{DM digestibility} = \frac{\text{AIA faeces (g/kg DM)} - \text{AIA feed (g/kg DM)}}{\text{AIA faeces (g/kg DM)}}$$

4.0 Results

4.1 Animal health

Between week-6 and week+4, one ewe died (pen 25) from post lambing complications. Other health issues included 2 ewes with lameness (pen 31 and pen 4) and these were treated with penicillin and one ewe in pen 36 (RC) had mild pre-partum prolapse. After lambing, four ewes presented with metritis and seven with mastitis. Mastitis cases are shown in Table 3.

Table 3. Mastitis cases

No. ewes	GS	LS	RC	UTWC/GS
Mild	1	2	-	1
Moderate	1	-	1	-
Severe	-	-	1	-

All cases were treated with antibiotics. Lambs on one GS ewe needed supplementation for two days until treatment took effect but both lambs were reared on the ewe. Lambs on one RC ewe needed supplementation for two days whilst treatment took effect but both lambs were reared on the ewe. That same ewe had severe mastitis so required on going treatment for a period of 7 days. The incidence of mastitis may seem relatively high but given the level of intervention at lambing time and the close monitoring of animal health in the first few weeks of lactation it seems likely that all cases of mastitis would be more readily identified than in a commercial situation.

Two lambs were born dead (pen 10 and pen 25). If a lamb died then a suitable lamb was fostered on to that ewe (from a triplet born to another ewe in the HAU flock) and the ewe remained in the trial. Ewes that reared only one lamb were removed from the trial. The ewe in pen 10 adopted another lamb at birth so remained in the trial. One lamb in pen 31 died after lambing and the ewe in pen 35 had a lamb removed, as she only reared one lamb because of mastitis. As a consequence, both ewes were removed from the trial. Ewes rearing one lamb were included in the trial until lambing (as they were expecting twins) and thereafter data collection stopped. A summary of ewes removed from the trial can be found in Table 4.

Table 4. Ewes removed from trial

Pen	Tag	Treatment	Reason for removal after lambing
25	2014-12	Grass	One lamb born dead and death of the ewe from post lambing complications
31	2011-16	Red clover	One lamb reared, one lamb died
35	2012-43	Grass	One lamb reared because of mastitis

4.2. Diet composition

The analysed chemical composition of the experimental forages used is presented in Table 5.

Table 5. Chemical composition of the silages

	GS	LS	RC	UTWC	GS & UTWC
pH	4.7	4.7	4.7	8.8	5.95
Dry matter	29	29	38	67	40.4
Ammonium N (% of total N)	1.2	2.8	1.0	17.7	3.1
Ether extract (%)	0.98	1.42	1.16	1.25	1.06
Ash (%)	10.0	13.2	10.0	4.8	8.4
NDF (%)	45.4	38.6	36.4	22.9	38.6
MADF (%)	30.2	31.0	25.4	17.1	26.3
CP (%)	17.1	19.6	18.8	14.6	16.3
Gross Energy (MJ/Kg DM)	17.93	17.89	17.94	18.01	17.95
Total Carbohydrate (g/kgDM)	724	655	727	769	738
NFE (g/Kg DM)	266	272	337	319	282
ME (MJ/Kg DM)	11.7	9.1	9.4	10.9	11.5
FME (MJ/Kg DM)	8.6	6.7	7.3	9.0	8.7
ERDP (g/Kg DM)	114	132	136	112	113
DUP (g/Kg DM)	19.5	19.1	17.5	16.5	18.6
NDF (g/Kg DM)	458	390	383	450	456

The predicted ME of the grass silage (GS) was very high. The legume silages (LS and RC) had very high levels of crude protein but relatively low ME. The DM of the different silages was stable during the trial except for the grass silage in week -2 which increased to 382 g/kg. This change in DM was taken into account in the calculation of total DMI. The red clover silage was not chopped at ensiling and chopping pre-feeding was discounted due to the time taken to chop on a daily basis. Hence ewes tended to drag some stronger, more fibrous stems out into the bedding. When refusals were weighed back every effort was made to collect these stems and include in the refusals but this added a small degree of uncertainty to the DMI measurements for the RC silage.

After the first two weeks on trial (week -8 to week -6) when ewes were acclimatising to the forages, body condition score of ewes on UTWC caused some concern with some ewes gaining condition and others losing condition. It was assumed that some ewes were selecting out the grain and leaving stems for shy feeders when in group feeding conditions. It was therefore decided to mix the UTWC on a 50:50 dry matter basis with grass silage.

Forage digestibility as measured by Acid Insoluble Ash is shown in Table 6.

Table 6: Forage digestibility of the diets offered prior to concentrates being fed

	GS	LS	RC	UTWC	SED	Significance
Digestibility	0.65a	0.59a	0.60a	0.73b	0.024	<0.001

N.B: means with the same letter (a,b) are not significantly different, those with different letters are significantly different. P Values, T=Trend, NS= Not Significant, *=P<0.05, **=P<0.01, ***=P<0.001.

4.3 Ewe performance

4.3.1. Dry matter intake

Dry matter intake (DMI) from forage and concentrates and total DMI for the different diets are shown in Table 7.

Table 7. Daily total dry matter intake (kg/ewe)

Treatment	GS			LS			RC			UTWC/GS		
kg DM/d	Forage	Conc.	Total	Forage	Conc.	Total	Forage	Conc	Total	Forage	Conc.	Total
Week -6	0.90	0	0.90	1.19	0	1.19	1.33	0	1.33	0.86	0	0.86
Week -5	1.14	0	1.14	1.32	0	1.32	1.79	0	1.79	1.42	0	1.42
Week -4	1.11	0.18	1.29	1.41	0.35	1.76	1.97	0.35	2.33	1.40	0.18	1.58
Week -3	1.00	0.18	1.18	1.40	0.35	1.75	1.87	0.35	2.22	1.30	0.18	1.48
Week -2	1.07	0.53	1.60	1.25	0.53	1.78	1.88	0.35	2.24	1.34	0.35	1.69
Week -1	1.04	0.61	1.65	1.12	0.65	1.77	1.80	0.43	2.24	1.19	0.43	1.63
Week +1	1.00	1.52	2.52	1.14	1.52	2.67	1.69	1.30	2.99	1.25	1.35	2.60
Week +2	1.37	1.17	2.55	1.32	1.52	2.84	1.65	1.30	2.95	1.43	1.17	2.60
Week +3	1.75	1.17	2.92	1.44	1.52	2.96	1.74	1.30	3.04	1.59	1.17	2.76
Week +4	2.12	1.17	3.29	1.52	1.52	3.04	2.01	1.30	3.31	2.01	1.17	3.19

Pre-lambing total DMI reached 2.2% of ewe body weight for GS, 2.95% for RC, 2.33 % for LS and 2.14% for UTWC/GS.
Post lambing total DMI reached 4.3 % for GS, 4% for LS, 4.35% for RC and 4.2% for UTWC/GS.
Table 8 shows the total DM consumed from forage and concentrates through the trial period for the four diets offered.

Table 8. Total feed used week -6 to week +4

kg/head	GS	LS	RC	UTWC/GS
Forage DMI –pre-lambing	43.8	53.8	74.5	52.6
Concentrate DMI pre-lambing	10.5	13.2	10.4	8.0
Cost £/ewe	6.1	9.4	9.3	6.8
Forage DMI post-lambing	43.7	37.9	49.6	44.0
Concentrate DMI post-lambing	36.0	42.7	36.5	34.1
Cost £/ewe	11.86	13.01	11.72	11.85
Total cost pre and post lambing	17.87	22.41	21.03	18.65

Costs based on GS @ £105/t DM, RC @ £105/tDM, LS @£140/tDM and UTWC/GS @ £108/tDM.

Table 9 shows the statistical analysis of forage dry matter intake across treatments. Intake of RC was consistently and significantly higher (P<0.001) than all other forages until week +2 when intakes of all other silages increased. Intake of GS was consistently lower than all other silages from week -5 until week -2.

Table 9. Daily total forage intake kg DM/ewe/day

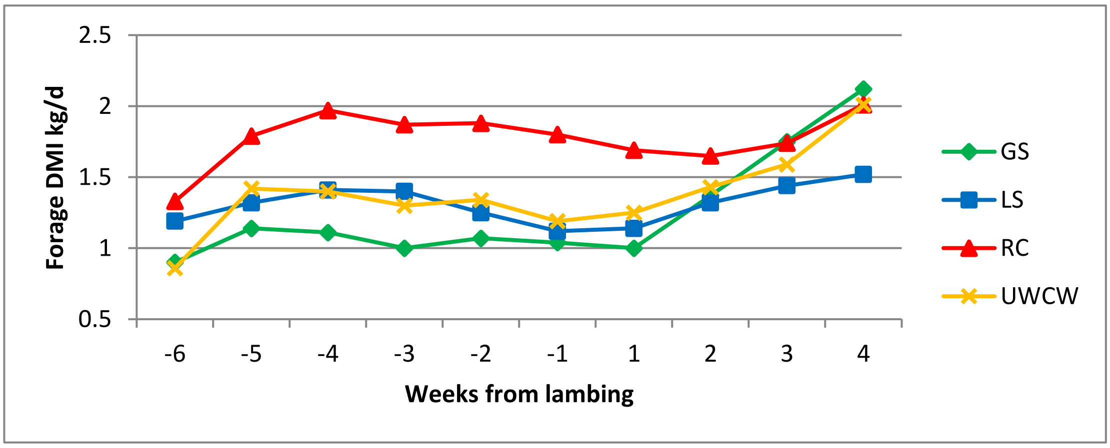
kg DM/d	GS	LS	RC	UTWC	SED	P	Signifiance
Week -6	0.90a	1.19b	1.33c	0.86a	0.036	<0.001	***
Week -5	1.14a	1.32b	1.79c	1.42b	0.081	<0.001	***
Week -4	1.11a	1.41b	1.97c	1.40b	0.112	<0.001	***
Week -3	1.00a	1.40b	1.87c	1.30b	0.128	<0.001	***
Week -2	1.07a	1.25ab	1.88c	1.34ab	0.145	<0.001	***
Week -1	1.04a	1.12ab	1.80c	1.19ab	0.138	<0.001	***
Week +1	1.00a	1.14ab	1.69c	1.25ab	0.129	<0.001	***
Week +2	1.37	1.3	1.65	1.43	0.150	0.160	NS
Week +3	1.75	1.44	1.74	1.59	0.157	0.177	NS
Week +4	2.12b	1.52a	2.01b	2.01b	0.184	0.013	*

Table 10 expresses forage dry matter intake from forage as a percentage of body weight both for the pre-and post-lambing periods. Intake of RC was higher than for all other silages throughout the trial.

Table 10. Average daily forage intake (% of body weight)

	GS	LS	RC	UTWC/GS
Week -6 to -1	1.15 (1.5%)	1.28 (1.68%)	1.77 (2.32%)	1.25 (1.64 %)
Week +1 to +4	1.56 (2.05%)	1.35 (1.78 %)	1.77 (2.32%)	1.57 (2.07%)

Figure 1. Forage DMI (kg/ewe/day)



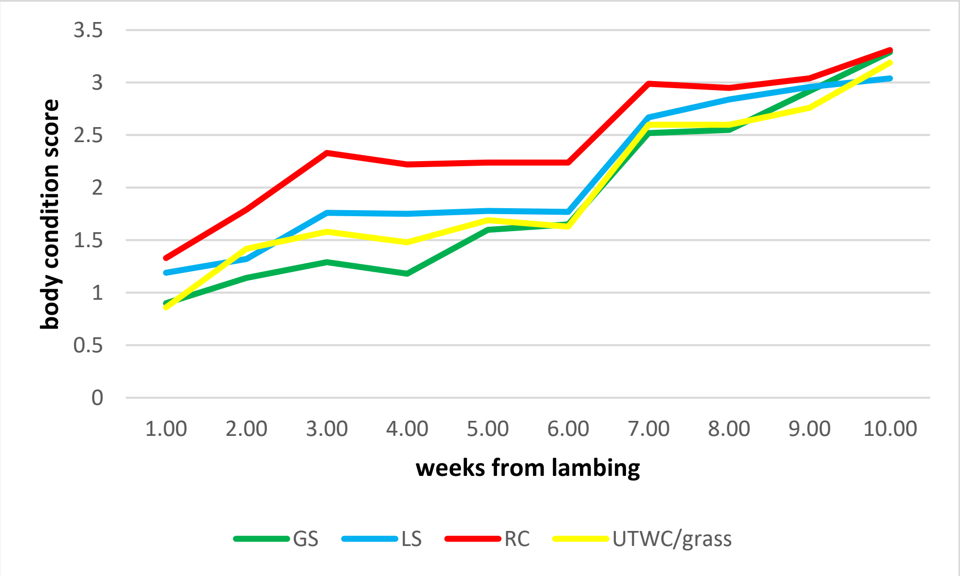
Total DMI was also recorded and is shown in Figure 2.

Data presented in Table 11 shows that total DMIs were highly significantly different and was highest for red clover and lowest for grass silage before lambing. Total DMI increased towards lambing as supplementary feeds increased, but then plateaued in line with forage DMI, increasing sharply post lambing with all groups showing similar DMI by week + 4.

Table 11. Total intake in kg DM /ewe/day

kg DM/d	GS	LS	RC	UWCW/GS	SED	P	Significance
Week -6	0.90a	1.19b	1.33c	0.86a	0.036	<0.001	***
Week -5	1.14a	1.32b	1.79c	1.42b	0.081	<0.001	***
Week -4	1.29a	1.76b	2.33c	1.58b	0.112	<0.001	***
Week -3	1.18a	1.75b	2.22c	1.48b	0.129	<0.001	***
Week -2	1.60a	1.78ab	2.24c	1.69ab	0.115	<0.001	***
Week -1	1.65ab	1.77ab	2.24c	1.63a	0.138	<0.001	***
Week +1	2.52a	2.67ab	2.99c	2.60ab	0.129	0.005	**
Week +2	2.55a	2.84abc	2.95c	2.60ab	0.150	0.032	*
Week +3	2.92	2.96	3.04	2.76	0.157	0.363	NS
Week +4	3.29	3.04	3.31	3.19	0.184	0.448	NS

Figure 2. Total DMI (kg/ewe/day)



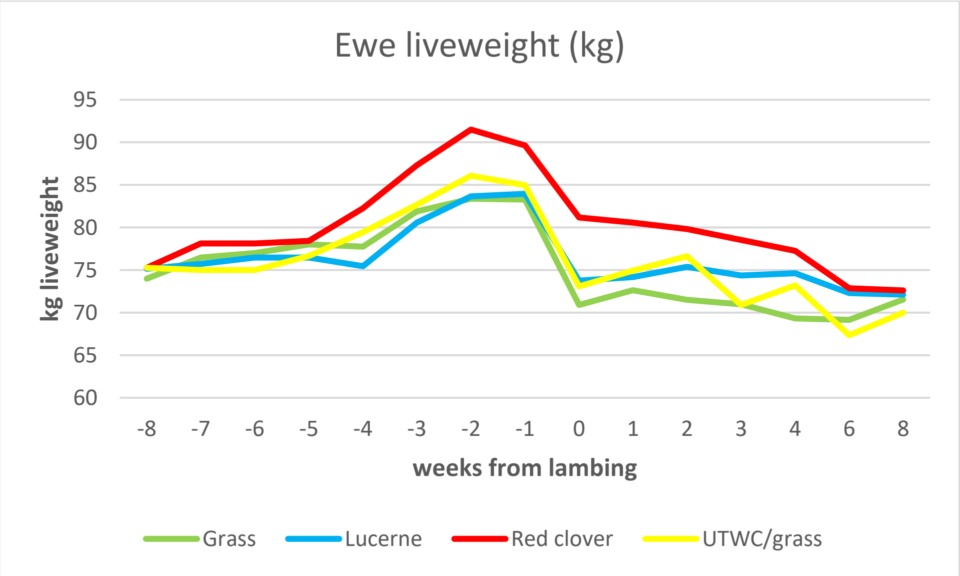
4.3.2 Ewe body weight

Ewes were weighed weekly and the results are shown in Table 12 and Figure 3.

Table 12. Ewe body weight and body weight change

week	Grass	Lucerne	Red clover	UTWC/ grass	SED	P	Significance
-8	74.73	75.17	75.25	75.25	2.318	0.940	NS
-7	76.46	75.71	78.12	75.00	2.394	0.602	NS
-6	77.00	76.46	78.42	76.67	2.560	0.869	NS
-5	78.00	76.83	80.29	79.96	2.454	0.455	NS
-4	77.75ab	75.45a	82.25b	79.46ab	2.426	0.056	Trend
-3	81.88a	80.58a	87.29a	82.67a	2.685	0.089	Trend
-2	83.38a	83.67a	91.50b	86.08ab	1.878	0.008	**
-1	83.29a	83.96a	89.65a	84.96a	2.514	0.069	Trend
12 hrs	70.92a	73.75a	81.17b	73.08a	2.622	0.003	**
1	72.62a	74.17ab	80.58b	74.93ab	2.430	0.015	*
2	71.51a	75.37ab	79.82b	76.62ab	2.435	0.017	*
3	70.99a	74.38ab	78.54b	70.92a	2.472	0.013	*
4	69.34a	74.62ab	77.27b	73.21ab	2.524	0.029	*
6	69.15	72.31	72.85	67.35	2.504	0.113	NS
8	71.56	72.12	72.61	70.01	2.840	0.814	NS
Wt change week -8 to week -1	8.92a	8.79a	15.15b	9.71a	1.700	0.002	**
Wt change 12hrs to 8 weeks	-0.01	1.94	5.39	3.58	2.39	0.16	NS

Figure 3. Ewe liveweight week -8 to week +8



Ewes on RC tended to gain more body weight between week -8 and week -1 than ewes on all other forages. Ewes on LS gained least body weight.

4.3.3 Body condition score

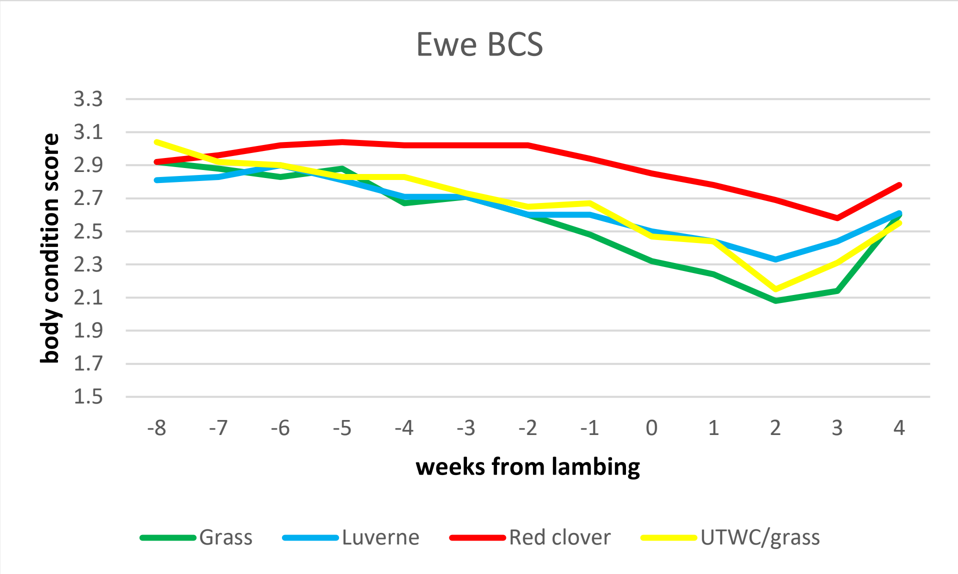
Ewes were body condition scored weekly from week -6 to week +4, (turnout) then at fortnightly intervals to weaning at 14 weeks.

Table 13. BCS and change in BCS pre and post-lambing

weeks from lambing	GS	LS	RC	UTWC /GS	SED	P	Significance
Week -8	2.92	2.81	2.92	3.04	0.103	0.072	Trend
Week -6	2.88	2.83	2.96	2.92	0.108	0.590	NS
Week -5	2.83	2.9	3.02	2.90	0.134	0.522	NS
Week -4	2.88	2.81	3.04	2.83	0.135	0.223	NS
Week -3	2.67	2.71	3.02	2.83	0.147	0.090	Trend
Week -2	2.71	2.71	3.02	2.73	0.148	0.112	NS
Week -1	2.60a	2.60a	3.02b	2.65a	0.145	0.018	*
12 h post lambing	2.48a	2.60ab	2.94b	2.67ab	0.147	0.027	*
Week +1	2.32a	2.50ab	2.85b	2.47a	0.137	0.004	**
Week +2	2.24a	2.44ab	2.78b	2.44ab	0.148	0.008	**
Week +3	2.08a	2.33ab	2.69b	2.15a	0.156	0.002	**
Week +4	2.14a	2.44ab	2.58b	2.31ab	0.149	0.038	*
Week +8	2.60	2.61	2.78	2.55	0.161		NS
BCS change week -8 to week -1	-0.32b	-0.21ab	0.10a	-0.40b	0.1219	0.001	***
BCS change 12hr to week +4	-0.25	-0.17	-0.42	-0.35	0.099	0.069	Trend
BCS change week +1 to week +8	0.14	0.02	-0.19	0.13	0.159	0.202	NS

RC ewes tended to maintain body condition better than ewes on other forages and were in significantly better condition at lambing (P<0.01) compared with GS or UTWC/GS fed ewes. BCS change between week +1 and week +8 post lambing showed no significant difference between groups but RC ewes tended to have lost more BCS over this period but having lambed at significantly higher BCS than GS fed ewes.

Figure 4. Ewe body condition score over time



4.3.4 Muscle depth

Muscle depth was not significantly different between treatments apart from in week -3 (P<0.01) indicating that ewes on red clover had a significantly greater muscle depth than ewes on the other three forages (Table 14).

Table 14. Muscle depth of twin bearing ewes fed four different forages pre and post-partum

Weeks from lambing	GS	LS	RC	UTWC/GS	SED	Significance
Week -6	2.441	2.427	2.496	2.58	0.0617	NS
Week -3	2.325^{ab}	2.182^{a}	2.575^{b}	2.307^{ab}	0.077	**0.009
Week -1	2.183	2.145	2.392	2.314	0.0871	NS
Pre-partum change	**-0.255**	**-0.279**	**-0.142**	**-0.263**	**0.245**	**NS**
Week +2	2.2	2.169	2.329	2.124	0.07226	NS
Week +4	2.103	2.174	2.258	2.179	0.07489	NS
Post-partum change	**-0.101**	**-0.013**	**-0.051**	**0.064**	**0.222**	**NS**

N.B: Anything with the same subscript is not significant. P Values, T=Trend, NS= Not Significant, *=P<0.05, **=P<0.01, ***=P<0.001.

Commencing at week -6 muscle depth had a range of 0.153cm between the four treatments and this was maintained over the trial with a final range during week +4 of 0.155cm. Ewes on red clover gained muscle depth between week -6 and week -3 unlike ewes on all other forages.

4.3.5 Fat depth

There were no significant effects of forage type on back fat depth throughput the trial. See Table 15.

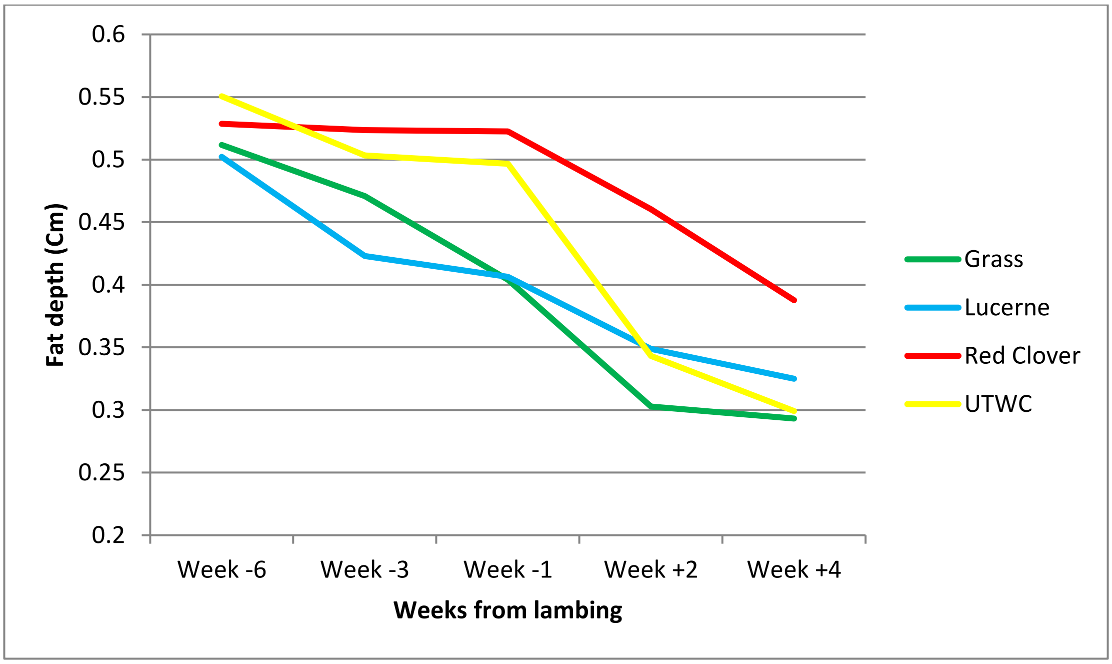
Table 15. Fat depth of twin bearing ewes fed four different forages pre and post-partum

Week from lambing	GS	LS	RC	UTWC/GS	SED	Significance
Week -6	0.5117	0.5022	0.5286	0.5506	0.0398	NS
Week -3	0.4708	0.4231	0.5236	0.5033	0.03729	NS
Week -1	0.4040	0.4063	0.52249	0.4966	0.04528	NS
Pre-partum change	**-0.105**	**-0.056**	**-0.009**	**-0.056**	**0.104**	**NS**
Week +2	0.3028	0.3488	0.4604	0.3432	0.04147	NS
Week +4	0.2932	0.325	0.3877	0.2992	0.03334	NS
Post-partum change	**-0.009**	**-0.023**	**-0.073**	**-0.043**	**0.084**	**NS**

N.B: Anything with the same subscript is not significant. P Values, T=Trend, NS= Not Significant, *=P<0.05, **=P<0.01, ***=P<0.001.

Back fat depth fell through the trial and was in line with condition score change with RC ewes maintaining condition better than ewes on all other forages but losing more body condition post lambing than ewes on other treatments (see Figure 5).

Figure 5. Back-fat depth



4.3.6 Blood analysis

Blood samples were taken form a selection of ewes at weeks -8, -6, -3, -1 , +2 and +4. Plasma glucose levels were only significantly different between forages in weeks -1 and +4. See Table 16.

Table 16. Level of plasma glucose pre and post-partum (mmol/l)

mmol/l	GS	LS	RC	UTWC/GS	SED	P	Signifiance
Week-8	2.65	2.53	2.90	2.76	0.266	0.565	NS
Week -6	2.42ab	2.33a	2.68b	2.54ab	0.127	0.078	Trend
Week-3	2.61	2.76	2.84	2.55	0.235	0.618	NS
Week -1	2.807abc	2.68ab	3.00c	2.59a	0.130	0.034	*
Week+2	3.15	3.01	3.06	3.19	0.300	0.933	NS
Week +4	3.40bc	3.13ab	2.85a	3.62c	0.220	0.018	*

At week -3 ewes were checked for ketone bodies using the Freestyle Optium H meter. RC clover ewes showed higher levels of ketones and hence were given slightly more supplement.

In terms of BHB there were no significant differences between forages throughout the trial period although BHB tended to be higher for RC than GS at week-3. At week +4 GS tended to show lower BHB than RC.

Table 17. Level of plasma BHB pre and post-partum (mmol/l)

mmol/l	GS	LS	RC	UTWC/GS	SED	P	Signifiance
Week-8	0.39	0.48	0.56	0.53	0.122	0.555	NS
Week -6	0.34	0.63	0.44	0.36	0.176	0.385	NS
Week-3	0.39a	0.53ab	0.63b	0.62b	0.091	0.072	Trend
Week -1	0.48	0.46	0.54	0.48	0.069	0.651	NS
Week+2	0.54	0.62	0.62	0.77	0.162	0.580	NS
Week +4	0.52a	0.84ab	0.96b	0.82ab	0.159	0.076	Trend

Total protein showed no significant difference between forages for all sampling occasions (Table 18).

Table 18. Level of plasma total protein pre and post-partum (g/l)

g/l	GS	LS	RC	UTWC/GS	SED	P	Significance
Week-8	56.8	58.5	56.4	57.3	4.64	0.971	NS
Week -6	58.5	58.0	65.3	60.9	7.34	0.743	NS
Week-3	63.5	61.0	56.1	58.2	4.75	0.461	NS
Week -1	61.1	51.2	58.7	58.8	6.54	0.479	NS
Week+2	66.8	66.6	68.5	66.6	7.61	0.993	NS
Week +4	58.3	54.4	63.7	57.3	5.38	0.395	NS

There was no significant difference in plasma albumin or plasma globulin at any point in the trial period (see Tables 19 and 120).

Table 19. : Level of plasma albumin pre and post-partum (g/l)

g/l	GS	LS	RC	UTWC/GS	SED	P	Signifiance
Week-8	26.7	26.4	24.7	25.8	1.121	0.336	NS
Week -6	25.7	25.7	25.7	25.7	0.951	1.000	NS
Week-3	24.7	25.5	25.6	25.9	1.108	0.745	NS
Week -1	23.4	25.2	25.8	25.0	1.073	0.189	NS
Week+2	28.8	28.8	28.8	28.6	1.534	0.999	NS
Week +4	28.9	29.6	30.1	29.0	1.064	0.622	NS

Table 20. Level of plasma globulin re- and post-partum (g/l).

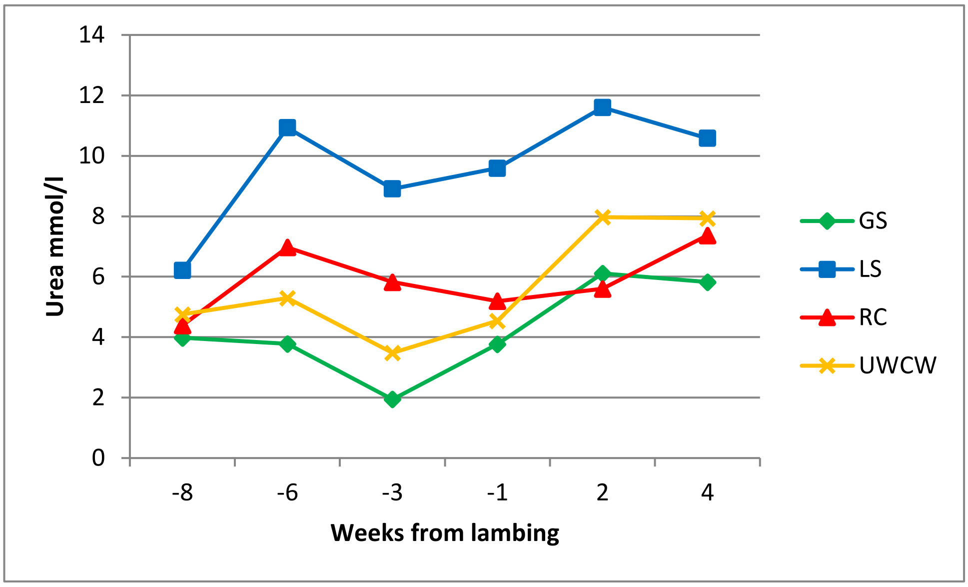
g/l	GS	LS	RC	UTWC/GS	SED	P	Signifiance
Week-8	30.0	32.0	31.6	31.5	4.96	0.979	NS
Week -6	32.8	32.3	39.6	35.3	7.89	0.783	NS
Week-3	38.7	35.5	29.6	32.3	4.79	0.293	NS
Week -1	37.7	26.0	32.9	33.8	7.16	0.457	NS
Week+2	38.0	37.8	39.7	38.0	8.34	0.996	NS
Week +4	29.4	24.8	33.6	28.3	6.02	0.549	NS

Plasma urea was consistently higher for LS ewes than all other treatments at all sampling dates and was significantly higher than GS (P<0.01) at weeks -6, -3 and +2 and significantly higher (P<0.05) in week -1 (see Table 21 and Figure 6).

Table 21. Level of plasma urea pre and post-partum (mmol/l)

mmol/l	GS	LS	RC	UTWC/GS	SED	P	Signifiance
Week-8	3.98	6.21	4.39	4.75	1.089	0.237	NS
Week -6	3.78a	10.93c	6.97ab	5.29ab	1.764	0.006	**
Week-3	1.94a	8.91c	5.82bc	3.48ab	1.800	0.008	**
Week -1	3.77a	9.59c	5.19abc	4.54ab	1.703	0.017	*
Week+2	6.11ab	11.60c	5.60a	7.97ab	1.614	0.008	**
Week +4	5.82a	10.58b	7.37ab	7.93ab	1.647	0.070	Trend

Figure 6. Plasma urea (mmol/l)



The results would suggest insufficient fermentable energy relative to rumen degradable protein in the LS diet compared to the other forages.

4.3.7 Ewe colostrum and milk yields

The colostrum yield and composition from ewes on each treatment at 16 hours *post-partum* is presented in Table 22. There were no significant differences between forages in terms of colostrum yield or composition.

Table 22. Colostrum yield and composition at 16 hours post-partum

	Yield	**Total solids**	**Fat**	**Protein**	**Lactose**	**Ash**	**Total solids**	**Fat**	**Protein**	**Lactose**	**Ash**	**Refrac**
	kg/day	g/kg	g/kg	g/kg	g/kg	g/kg	g/day	g/day	g/day	g/day	g/day	%
GS	1.829	233.7	10.1	85.91	129.6	8.70	436.7	18.36	161.5	249.1	15.5	15.83
LS	1.748	217.8	8.8	74.71	125.9	8.40	420.4	17.00	144.4	245.9	16.6	14.00
RC	2.008	236.7	9.8	85.82	132.4	8.62	611.8	19.83	172.3	275.7	21.0	16.82
UTWC /GS	1.702	226.6	12.9	82.21	122.9	8.60	465.9	29.22	168.2	255.2	16.7	15.31
SED	0.416	24.68	2.97	9.07	16.77	0.399	119.7	9.24	27.04	52.40	2.94	1.281
P	0.527	0.874	0.562	0.576	0.945	0.895	0.379	0.490	0.745	0.941	0.270	0.199

*Refra – a refractometer was used to assess the density of colostrum.

All refractometer readings indicated good quality colostrum.

4.3.8 Milk yield and composition

The milk yield and milk composition of ewes on each treatment at 21 days *post-partum* is presented in Table 23. There were no significant differences in milk yield or composition between treatments.

Table 23. Ewe milk yield and composition at 21 days post-partum

	Yield	Total solids	Fat	Protein	Lactose	Total solids	Fat	Protein	Lactose
	kg/day	g/kg	g/kg	g/kg	g/kg	g/day	g/day	g/day	g/day
GS	2.49	199.0	65.33	39.00	49.47	507.0	163.4	99.6	128.6
LS	2.55	204.0	67.80	37.87	52.40	520.9	171.6	96.6	136.5
RC	2.66	191.2	63.60	36.20	46.59	553.5	187.4	105.0	132.9
UTWC/GS	2.73	195.3	63.64	38.07	48.35	577.1	192.7	110.6	141.5
SED	0.620	15.77	7.210	2.890	3.990	140.60	48.98	26.87	34.89
P	0.964	0.828	0.931	0.712	0.528	0.916	0.868	0.911	0.973

4.3.9 Ewe faecal egg counts and eosinophils

The faecal egg counts (FEC) and blood eosinophil counts of 6 ewes per treatment are shown in table 24.

Table 24. Effect of forage type on FEC and eosinophil levels in pregnant and lactating ewes

	Treatment and treatment means					
Week pre partum/post-partum & test	GS	LS	RC	UTWC/GS	SEM	P Value
- 8 Eosinophil	0.83 (7.73)	0.79 (6.90)	0.70 (5.70)	0.86 (7.96)	0.090	NS
- 6 FEC eggs/g faeces	2.08 (158)	0.95 (50)	1.80 (142)	1.01 (58)	0.373	NS
- 3 FEC	2.43 (412)	1.06 (117)	2.21 (416)	2.06 (142)	0.353	NS
- 3 Eosinophil	0.75 (5.30)	0.60 (3.19)	0.75 (5.13)	0.83 (5.85)	0.071	NS
- 1 FEC eggs/g faeces	2.44 (508)	1.57 (200)	2.36 (787)	2.33 (267)	0.378	NS
- 1 Eosinophil	0.80 (6.07)	0.77 (5.55)	0.83 (6.15)	0.85 (6.14)	0.077	NS
+ 2 FEC eggs/g faeces	2.06 (396)	1.46 (138)	2.27 (695)	2.38 (325)	0.424	NS
+ 4 FEC eggs/g faeces	1.39 (358)	1.35 (105)	2.21 (695)	2.17 (229)	0.466	NS
+ 4 Eosinophil	0.62 (3.27)	0.70 (4.20)	0.80 (5.50)	0.67 (3.95)	0.054	NS

Note. all results have been transformed to Log_{10} (Count +1) figures. Bracketed figures are actual figure i.e. FEC in epg, eosinophil number m/mm^3.

There were no significant differences between treatments at any time point for FEC or eosinophils but at week -6 (P=0.11), and week -3 (P=0.057) there was a trend for GS and RC to have higher FEC than LS and UTWC/GS. Results were highly variable. RC ewes tended to have higher FEC post-lambing than ewes on the other forages.

4.4 Lamb performance

Lamb birth weights were not statistically different between treatments but those born to grass silage fed ewes tended to be heavier. Lamb growth rate was also not statistically significantly different between treatments although RC lambs tended to grow faster than the other three treatment groups to 8 weeks and weaning (at 14 weeks). All lambs were creep fed *ad-libitum* from turn out (4 weeks) through to weaning, although intakes were low.

Table 25. Twin lamb birth weight and growth from birth to weaning

kg	GS	LS	RC	UTWC/GS	SED	P	Significance
12 hr birth weight	5.35	5.06	4.82	4.90	0.225	0.116	NS
DLWG 0 - 8 weeks	0.259	0.279	0.304	0.275	0.0178	0.117	NS
DLWG 0 - 14 weeks	0.255	0.285	0.293	0.288	0.0150	0.071	Trend

5.0. Discussion

All forages as supplemented provided an adequate diet for pregnant, twin bearing ewes before lambing without protein supplementation as measured by live weight change, body condition score, blood metabolites and lamb performance. Levels of supplementation varied from those used by Speijers *et al* (2005) where all ewes were given the same level of molassed sugar beet pulp shreds (SBP) rising from 0.25 kg at 6 weeks pre-lambing to 1.12 kg at lambing irrespective of forage DMI or forage quality. In this trial levels of supplementary feeding (SBP and barley) were adjusted according to forage DMI resulting in much lower levels of supplementation and more cost effective diets. In accordance with the results of Speijers *et al* (2005) intake of RC was far higher than for GS, however intake of LS was similar to GS. Fraser *et al* (2000) and Paul *et al*. (2002) attributed this to a high particle breakdown within, and rate of passage from, the rumen. The forage DMI on RC between 6 and 0 weeks before lambing was very high at almost 1.8kg (2.3% of body weight) compared to 1.15 to 1.28kg on the other three forages. This compared to 1.32 (1.8% of body weight at 6 weeks pre-lambing), 1.28 and 0.76 kg for RC, LS and GS respectively for the same period in the Speijers *et al* trial. The long chop length of the red clover in the current study did cause some practical issues but stems pulled on to the bedding were gathered up and weighed back each week to minimise inaccuracies in forage intake measurements.

The very high intake of RC in this trial, (with ewes penned individually and never allowed to run out of forage) may not be totally representative of ewes in a commercial situation where feed access and competition between ewes in a group can reduce average intake. However producers using this type of silage should budget for at least 1.5 times the quantity of grass silage. The extra forage should be costed against the additional concentrates required on the other treatments.

FEC results indicated no significant difference between forages but results were very variable and ewes on RC tended to have higher FEC results despite being in better condition and having high DMI. FEC results remained very low for LS ewes throughout the trial.

Lamb performance compared well to performance reported in Speijers *et al* (2015) with a significant difference in growth rate to 3 weeks of age but with a trend for lambs born to ewes fed red clover to perform better than lambs born to either Lucerne or grass silage fed ewes.

Lamb growth (g/day)		**Lucerne**	**Red clover**	**Ryegrass**	**SED**	**Significance**
Birth to 3 weeks	Speijers *et al*	320	323	282	15.8	*
Birth to 12 weeks	Speijers *et al*	284	311	301	11.2	Trend
Birth to 14 weeks	Phillips *et al*	285	293	255	15.0	Trend

6.0 Conclusions

- Intake of red clover silage was significantly higher than for all other forages
- High intake of red clover silage will impact on forage required pre-lambing and costs
- Intake of grass silage was low in this trial
- Ewes on red clover maintained body weight and condition pre-lambing better than ewes on grass silage
- Ewes on all the four forages performed satisfactorily without protein supplementation pre-lambing suggesting that all diets provided adequate metabolisable protein.
- Ewes on lucerne silage showed significantly higher blood urea than ewes on all other treatments suggesting an inadequate supply of fermentable energy to capture the high level of rumen degradable protein supplied.
- Lamb performance compared well to other published work on similar silages.

For producers considering growing any of these crops, the cost of establishment and longevity of the sward needs to be evaluated carefully as does the value of aftermath grazing for finishing lambs on grass, red clover or lucerne. The high feed costs associated with red clover in this trial (due largely to high forage consumption) for pregnant ewes could well be mitigated by higher growth rate in lambs on aftermaths. The better ewe performance of the RC ewes, in terms of body weight and condition, raises the question whether the predicted ME of the red clover silage was accurate and whether supplementation was too high. Anecdotally commercial sheep farmers are successfully feeding red clover alone to pregnant ewes. A further trial is planned to evaluate red clover silage when fed alone and with varying levels of supplementation.

7.0 References

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Final Report

Full Report

Q1: Financial reporting –

	Yes	No	N/a
Was the project expenditure in line with the agreed budget?	x		
Was the agreed split of the project budget between activities appropriate?	x		

If you answered no to any of the questions above please provide further details:

Q2: Milestones – were the agreed milestones completed on time?

Project milestones	Proposed completion date	Actual completion date

If any of the milestones above are incomplete/delayed, please provide further details:

Q3: Results – what did the work find?

The work confirmed that all silages can be suitable forages for ewes in late pregnancy with no protein supplementation and that similar rates of lamb growth were achieved across treatments. Ewes on red clover tended to gain more weight and maintain body condition better than ewes on grass silage. Lambs born to red clover ewes tended (NS) to grow faster than lambs on other treatments. Dry matter intake of ewes on red clover far exceeded DMI on the other forages.

Q4: Discussion – what do the results mean for levy payers?

Red clover silage is a high protein forage that can be fed to ewes in late pregnancy with no additional protein supplementation and only low levels of energy rich feeds (barley and beet pulp) in the last four weeks before lambing. Dry matter intakes of red clover were significantly higher than for the other forages and this must be taken into account when calculating the cost of late pregnancy and lactation rations.

Q5: New knowledge – what key bit of new knowledge that has come out of this project so far?

The trial has confirmed that red clover, lucerne and urea treated whole crop wheat can be used for pregnant and lactating ewes. Ewes tended to sort out grains in the UTWC and body condition of ewes varied so this forage was offered with grass silage rather than alone. Performance on the red clover was particularly good pre-lambing with ewes on RC plus barley and beet pulp gaining more weight and maintaining body condition better than ewes on the other treatments. This was attributed to the very high DMI of this silage.

Q6: Gaps in knowledge – what gaps in knowledge has this project currently identified?

Further work is required to understand whether RC silage can be successfully fed without supplementation to ewes in late pregnancy. This is likely to depend on the quality of the silage and the protein content, and a trial to compare different red clover silages of varying ME, ERDP and DUP content could prove worthwhile. There remains some doubt about the reliability of laboratory analysis of forage legumes. Full costing of growing, harvesting and feeding of forage legumes for ewes in late pregnancy and early lactation would be valuable to help producers focus on the most cost effective diets.

Q7: Additional deliverables – what activity is planned with the results from this project?

Activity	What is planned?	When likely to happen?
Events		

Press articles		
Conference presentations, papers or posters	**Paper for BSAS 2018**	
Scientific papers		
Other		
Other		