Final Report 2016

Use of home grown protein sources and protein protection technologies to optimise protein nutrition of ewes

Summary sheet (up to two pages)

Project number			
Start date	September 2012	**End date**	March 2016

Project aim and objectives

Initial project:

1. To determine the metabolisable protein (MP) requirements of prolific periparturient ewes and the absorbed amino acid supply from forages and home grown protein sources (desk study).
2. To determine production responses of prolific ewes to additional MP supply by increasing effective rumen degradable protein (ERDP) or digestible undegradable protein (DUP) supply.
3. To assess protein protection technologies to enhance MP supply from home grown proteins.
4. To design concentrate supplements to satisfy the MP requirements of prolific periparturient ewes offered different basal forages using home grown protein sources.
5. To provide guidelines and recommendations for stakeholders on home grown protein and protein protection technologies to optimise ewe protein nutrition in different feeding systems.
6. To design and test a novel concentrate delivery system for supplementation of ewes 'at grass'.

Project extension:

7. To investigate the effect of variation in body condition score (CS) on the response of ewes to additional DUP supply during late pregnancy and early lactation.
8. To relate subjective changes in ewe body weight (BW) and body CS to objective measurements of back fat and eye muscle depth using ultra sound scanning.
9. To investigate the effect of increased protein demand arising from parasite challenge on the response of ewes to additional DUP supply.
10. To undertake farm based trials to demonstrate the benefits of DUP supplementation under varying field conditions.

Key messages emerging from the project

1. MP requirements of prolific periparturient ewes may be 20-30% greater than suggested by AFRC (1993) as a result of increased lamb birth weight and milk production.
2. Xylose-treated rapeseed meal, and to a lesser extent micronized faba beans, have great potential to reduce reliance on protected soya bean meal (SBM) to meet MP requirements.
3. DUP supplementation to improve productivity is sensitive to other drivers of protein scarcity, and for ewes in poor condition and under worm challenge results in production responses.
4. Daily supplementation with protected protein can be replaced by feeding every other day without impacting on performance, resulting in much needed labour saving around lambing.

Summary of results (note that numbers used here refer those under Project aim and objectives)

1. The desk study indicated that MP requirements for terminal sire mated, prolific ewes are likely to be 20-30% greater than AFRC (1993) estimates, largely due to heavier lambs. Calculations showed sensitivity of intestinal amino acid supply to DUP content, suggesting that protein quality, i.e. essential amino acid composition, is increasingly important for high DUP diets.
2. Using SBM and xylose-treated SBM (SoyPass®) as models, we observed that early lactation production responses were only modestly more sensitive to DUP than to ERDP.
3. The desk study summarised several protein protection technologies; especially browning with xylose and formaldehyde treatment show great opportunities to more than double DUP content.
4. Novel high-DUP concentrate supplements (up to 56 g DUP/kg), resulting from increased levels of SoyPass®, xylose-treated rapeseed meal (RaPass®), micronized field beans, and mixtures thereof, doubled daily DUP supply in rations with different forage backgrounds but failed to

increase lamb weaning BW. The absence of effect of protein source supports the view that home grown protein sources can be used to reduce reliance on SBM in ewe diets. 5. The outcomes of this program of work is informing the revision of the "Feeding the ewe" booklet, currently underway with support from AHDB Beef & Lamb, and have been used in a number of end-user activities (Farmer Discussion Groups, Open Days, Farm Trials). 6. To feed high DUP pellets in lactation post turnout (~22% DUP), we tested "3-in-1 feeders", systems that allow 24-h access to supplements but restrict intake by making ewes work hard to extract grains from a narrow aperture. Despite sustained efforts, pellets could not be made hard enough to avoid them absorbing environmental water inside the feeder, resulting in bridging and blocking the flow. Indirectly, this project contributed to the development of high DUP feed blocks based on protected SBM, now available to farmers wishing to supplement DUP at grass. 7. When ewes were managed to reduce body CS by 0.5 units during mid-pregnancy, benefits of DUP supplementation on ewe performance were observed; for thin ewes, additional DUP supply increased lamb birth weight, colostrum component yields, and subsequent lamb performance to a larger extent than for fit ewes. 8. Body condition scoring provides a good subjective indication of back-fat depth. The strong relationship between back-fat and eye-muscle depth suggest that composition and energy value of ewe BW change remains relatively constant across a range of CS. Further work is required to clarify relationships between CS, scanning results and nutrient balance in different breeds. 9. It was observed that ewe DUP supplementation did improve litter weaning BW when ewes were exposed to worm challenge upon turn out following periparturient housing in the absence of worm challenge. Unexpectedly, this was not the case for ewes who were under continued challenge during the periparturient period. 10. Building on earlier trial work demonstrating that daily volume of SBM can be reduced by 50% when using protected SBM (Sopralin®), farm trials carried out showed that feeding daily protected SBM can be replaced with 3x weekly feeding without impact on ewe productivity. Both outcomes are providing farmers opportunities to reduce costs, save labour and trough space.

Lead partner	Scotland's Rural College (SRUC)
Scientific partners	Harper Adams University (HAU)
Industry partners	None
Government sponsor	None

Has your project featured in any of the following in the last year?	
Events	***Press articles***
The project has featured in seven end-users events, including Farmer Discussion Groups, Open Days, Agricultural Shows and Workshops; a detailed list is presented in the full report (Q3; Outputs).	The project has featured in eight articles in trade journals, including Scottish Farmer, Sheep and Beef Producer, Daily Post, Grass & Forage Farmer; a full list is presented in the full report (Q3; Outputs).
Conference presentations, papers or posters	***Scientific papers***
The project has resulted in ten papers presented at Annual Meetings of British Society of Animal Sciences (BSAS) and British Grassland Society (BGS), including at special sessions organised by AHDB Beef & Lamb; a detailed list is presented in the full report (Q3; Outputs).	The expectation is that up to four scientific papers will be resulting from this work over the next two years (Q3; Outputs).
Other	
None	

Full Report

Q1: Financial reporting –

	Yes	No	N/a
Was the project expenditure in line with the agreed budget?	✓		
Was the agreed split of the project budget between activities appropriate?	✓		
If you answered no to any of the questions above please provide further details: **N/A**			

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

Project milestones	**Proposed completion date**	**Actual completion date**
Use of home grown protein sources and protein protection technologies to optimise protein nutrition of ewes		
1. Completion of desk study	Jan 2013	SRUC: Sep 2014
2. Completion of data analysis of year 1 experiments and presentation to PSG	Dec 2013	HAU: Jul 2014 SRUC: Sep 2014
3. Completion of data analysis of year 2 experiments and presentation to PSG	Dec 2014	HAU: Feb 2015 SRUC: Jan 2014
4. Conclusion of cost-benefit analysis	Feb 2015	Carried over
5. Completion of sign of KE material and final report	March 2015	Carried over
The effect of body condition and protein demand on the response of ewes to digestible undergradable protein (DUP) supply (extension)		
1. Interim report –preliminary results of ewe trial (animal performance)	May 2015	HAU: May 2015 SRUC: Sep 2015
2. Final report of ewe trial (chemical analysis)	Dec 2015	HAU: Nov 2015 SRUC: Aug 2016
3. Conclusion of cost benefit analysis (carried over from previous project)	March 2016	SRUC: Sep 2016
4. Final report – All research findings including report on demo farms	April 2016	HAU: Jul 2016 SRUC: Sep 2016
If any of the milestones above are incomplete/delayed, please provide further details: No significant delays occurred during the project regarding trial work. All trials were conducted as planned and results presented to PSG. Completion dates above reflect dates of final report for each trial. Overall final reporting slightly delayed due to personal circumstances SRUC lead, though outcomes have been circulated to the PSG in a timely manner.		

Q3: Results – what did the work find?

The desk study was conducted at SRUC from October 2012 to September 2014. Three experiments were conducted at HAU and at SRUC between January 2013 and November 2015 to investigate the effect of level and source of protein supply on ewe and lamb performance under differing conditions in terms of type of forage, ewe body condition and worm challenge. Three farm trials were designed in 2015 on frequency of protected proteins supplementation. One trial changed into a case study, due to high PAL silage. Detailed reports on each activity have been presented to AHDB Beef and Lamb. Presented here is a summary.

Desk study (SRUC)

This desk study was undertaken to assess the feasibility of using protein protection technologies to improve periparturient MP supply from home grown protein sources. To this effect, the reassessment of periparturient MP requirements clearly illustrated that at current levels of productivity AFRC (1993) guidelines underestimate MP requirements, and that in particular the MP requirements of terminal sire tupped Mule ewes are 15 to 25% greater than AFRC (1993) estimates. An overview of protein protection technologies has shown that formaldehyde and xylose treatment is most popular to increase raw material DUP, and there are opportunities to explore using protected RSM as a home-grown replacement for SBM. Heat treated beans may also be a good alternative, though performance studies have yet to be carried out to demonstrate such feasibility. Lastly, the theoretical appraisal of the consequences of protein protection technologies on small intestinal amino acid supply from selected protein sources has illustrated that as DUP levels increase, intestinal amino acid supply also increase but that its amino acid balance changes. As such, care needs to be taken to ensure amino acids are balanced, though what constitute a balanced MP in lactating sheep remains largely unknown.

2013 HAU Experiment 1: Effect of forage type and level and source of protein supply on ewe and lamb performance during late pregnancy and early lactation.

A 2 x 3 factorial experiment was conducted to investigate the effect of forage type and protein supply on ewe and lamb performance. Forty eight twin-bearing Suffolk x Mule ewes (85.0 kg) were allocated to either hay (H) or straw (S), and one of three concentrate feeds formulated to provide either a low or high level of protein supply from either soya bean meal (SL, SH), or a high protein supply from rape seed meal (RH), but similar levels of metabolisable energy (ME), fermentable ME (FME) and effective rumen degradable protein (ERDP). Concentrate SL contained 188 g/kg DM crude protein (CP) and 26 g/kg DM digestible undegradable protein (DUP), whereas concentrates SH and RH contained 226 g/kg DM CP and 57 g/kg DM DUP. Forages were fed at 0.5 and 0.8 kg/day during pregnancy and lactation respectively, with concentrates being fed to meet predicted ME requirements. Diets HSL and SSL supplied 1.0 and 0.8, whereas diets HSH, HRH, SSH and SRH supplied 1.25 and 1.0 of calculated MP requirements during pregnancy and lactation respectively (AFRC, 1993).

Forage type had no effect on *pre-partum* ewe BW and CS change, but ewes offered S lost more condition *post-partum* than those offered H (1.38 vs 1.13). Similarly, forage type had no effect on colostrum component yields, but ewes offered S had higher total solids (TS) (675 *vs* 563 g/day), fat (365 *vs* 291 g/day) and protein (155 *vs* 136 g/day) yields than those offered H. Ewes offered concentrates SH and RH had higher *pre-partum* BW gains than those offered concentrates SL (7.70, 7.39, *vs* 5.41 kg) and lower CS loses (0.51, 0.45 *vs* 0.62). Similarly, ewes offered concentrates SH and RH had higher colostrum TS, fat and protein yields than those offered concentrates SL TS 887, 701 *vs* 571 g/day; fat 424, 343 *vs* 267 g/day; protein 312, 226 *vs* 178 g/day. However, there was no effect of protein supply on milk component yield an no effect of either forage type or protein supply on lamb birth weight, lamb growth rate or ewe faecal egg output (FEC). Overall, both forage type and protein supply influenced ewe performance, but had no effect on lamb performance.

2013 SRUC Experiment 1: To assess whether ewe performance is more sensitive to DUP rather than to CP or MP *per se*.

Thirty-two twin-bearing Texel-tupped 2-3 parity Scottish mules, with average BW, CS and faecal egg count (FEC with 95% CI) of 77.3±2.1 kg, 2.85±0.05 and 225 (194-261) epg at day -41 (day 0 is parturition) were housed individually and allocated to one of four feeding treatments until day 30 of lactation. The feeding treatments 1, 2, 3 and 4 were formulated to supply 137, 157, 178 and 157 g CP, 87, 93, 107 and 107 g MP, and 29, 34, 41, and 49 g DUP per kg restrictedly fed mixed ration. The latter consisted of 300 g/kg hay and 700 g/kg concentrates, to which additional soya bean meal or SoyPass® were included by replacing appropriate amounts of beet pulp, soya hulls and protected fat to formulate feeding treatments 2 to 4. Ewes were not dewormed at housing, to assess treatment effects on naturally acquired gastrointestinal nematode infections. Ewes were condition scored, faecal sampled for FEC fortnightly and weighed weekly, whilst lambs were weighed at birth, twice daily until day 3 and weekly thereafter. Performance and log-transformed FEC data were analysed using ANOVA with orthogonal contrast statements to assess linear and quadratic effects of feeding treatments, using initial BW, CS and FEC as covariates.

Feeding treatment linearly affected ewe BW gain during late pregnancy and early lactation, with final ewe BW for treatments 1, 2, 3 and 4 averaging 62.1, 63.2, 65.7 and 66.3 kg, respectively (s.e.d. 1.68 kg; P=0.013). A similar tendency was observed for litter BW gain from day 3 onwards, averaging 618, 645, 686 and 664 g/day, respectively (s.e.d. 30 g/day; P=0.068). Feeding treatments did not affect litter birth weight and BW gain over the first three days, i.e. a proxy of colostrum production. Feeding treatment and its interaction with time were not significant for FEC (P>0.50), which averaged 356 (314 to 404) epg during late pregnancy and 366 (316-424) epg during lactation. Feeding treatments also did not affect plasma pepsinogen levels, averaging at 567±58 mU/l.

The absence of strong quadratic effects of feeding treatment on ewe performance data supports the view that ewe performance may be more sensitive to DUP nutrition than to CP or MP nutrition per se. Effects on ewe BW gain and CS were more pronounced than those on litter BW gain, which is consistent with the view that milk production may take priority over maintenance of body reserves (Houdijk *et al.,* 2001). However, the magnitude of feeding treatment effects, especially on litter BW gain, were smaller than those observed in earlier studies (e.g. Kidane *et al.,* 2010), which likely arose from a smaller degree of MP scarcity for feeding treatment 1. It can not be excluded that the latter may have contributed to the lack of feeding treatment effect on ewe FEC. The level of FEC and pepsinogen combined suggest that the parasites present were more likely to be small intestinal than abomasal. As such, the lack of effects of feeding treatment on FEC would be consistent with a smaller sensitivity to host protein nutrition for small intestinal infections than for abomasal infections (Houdijk *et al.,* 2009). Furthermore, the absence of significant challenge in the current experiment may also have contributed to the smaller than expected effects of varying CP, MP and DUP on ewe performance.

2014 HAU Experiment 2: Effect of level and source of protein supply on ewe and lamb performance during late pregnancy and early lactation.

A 2 x 3 factorial experiment was conducted to investigate the effect of level and source of protein supply on ewe and lamb performance. Forty eight twin-bearing Suffolk x Mule ewes (84.2 kg) were fed on a silage based diet with one of six concentrates formulated to supply either a low (L) or high (H) level of protein either soya bean meal (S) rape seed meal (R) or field beans (B) as the main protein sources. All concentrates were formulated to supply similar levels of ME, FME and ERDP. However, concentrates L was formulated to provide 180 g/kg DM CP and 28 g/kg DM DUP, and concentrates H were formulated to provide 212 g/kg DM CP and 56 g/kg DM DUP. For treatment B, the latter required addition of some protected soya. Silage was fed at 0.5 and 1.0 kg/day DM during pregnancy and lactation respectively, with concentrates being fed to meet ME requirements. Diets L supplied 1.0 and 0.8, whereas diets H supplied 1.25 and 1.0 of calculated MP requirements during pregnancy and lactation respectively (AFRC, 1993).

Level of protein supply had no effect on ewe and lamb performance. Similarly, source of protein supply had no effect on lamb performance, but variable effects on ewe performance. Ewes offered concentrates S tended to be in better condition at the end of the experiment (BW 75.0 *vs*

71.0 and 72.0; CS 3.02 *vs* 2.43 and 2.56; back-fat 4.1 *vs* 3.4 and 3.3 mm and eye-muscle depth 22.7 *vs* 22.0 and 20.7 mm) at week +8 *post-partum* than ewes offered concentrates R or B. CS was found to be linearly related with ultrasound fat and muscle depth. Data indicate that at CS 3, ewes were predicted to have a fat depth of 6.5 mm and a muscle depth of 23.7 mm, and that one unit of CS reduction being equivalent to 5.8 mm fat depth and 3.7 mm muscle depth loss. Level of protein supply had no effect on ewe colostrum or milk component yields. However, ewes offered concentrates R had higher milk component yields (TS 716 *vs* 626 and 556 g/day; fat 278 *vs* 235 and 204 g/day; protein 145 *vs* 128 and 117 g/day) than those offered concentrates S and B respectively. This may have resulted from minor differences between diets in digestibility and energy supply. Level and source of protein supply had no effect on lamb birth weight or subsequent lamb performance. The FEC of all ewes was low and relatively constant throughout the experiment, and there was no effect of experimental treatment on FEC or immune status.

Overall, additional protein supply, above requirement, had no effect on ewe and lamb performance, but source of protein supply may have influenced ewe performance. Home growth protein sources such as rape seed meal or field beans can be used to reduce reliance on soya bean meal in ewe diets.

2014 SRUC Experiment 2: Effect of late pregnancy and/or early lactation DUP supplementation on ewe and lamb performance until weaning.

Multiple-bearing Texel-mated Scottish mules, with mean BW of 81.4±1.1 kg and CS of 3.10±0.05 at day-48 (day 0 is parturition), were housed individually. They received iso-energetic rations (400 g/kg hay; 600 g/kg concentrates) at 0.85 times energy requirements (AFRC, 1993), calculated to supply 0.85 (L) or 1.20 (H) × MPr (n=24). Half of each group switched to the alternative treatment at lambing, resulting in four feeding treatment combinations during lactation (n=12). A 2:1 mixture of xylose-treated rapeseed meal (RaPass®) and soya bean meal (SoyPass®) was used to increase DUP levels from 28 to 52 g/kg. From day 7, ewes grazed one of eight 0.5 ha new grass-clover pastures (six ewes and their 12 lambs each), where H ewes were fed a pellet with 600 g/kg RaPass® and 300 g/kg SoyPass® at 400 g/head/day until day 58, supplied in a 3-in-1 feeder. Housed ewes were weighed weekly and CS was taken fortnightly; lambs were weighed at birth and at day 7. During grazing, ewes and lamb BW, and ewe CS, were taken on day 24, day 58 and day 100. Ewe herbage dry matter intake was measured using the n-alkanes methodology. Data were analysed using monofactorial ANOVA during pregnancy and 2×2 ANOVA during lactation, with ewes and plots as experimental units before and after day 7, respectively.

Feeding more DUP during pregnancy increased ewe BW from 88.4 to 91.6 kg (s.e.d. 0.98 kg; P=0.002) before parturition, which carried over into early lactation but did not significantly increase litter birth weight, averaging at 10.3±0.25 kg. Ewe CS was not significantly affected. Feeding more DUP during lactation did not affect litter BW gain, which averaged 550±17 g/day but increased ewe BW on day 58 from 74.3 to 78.4 kg (s.e.d. 0.94 kg; P=0.035), though at weaning this effect disappeared. Feeding treatments did not affect herbage intake, which averaged 2.89±0.12 kg/d. Feeding more DUP during pregnancy did carry over into lactation on plasma albumin concentrations, increasing from 27.5 to 32.6 g/l (s.e.d. 0.4 g/l; P=0.003) by day 58.

In this experiment, DUP supplementation temporarily increased ewe BW but did not affect litter BW gain. Since ewes had high CS, were worm-free at housing and grazed parasitologically clean pastures, the lack of DUP response may be due to high body reserves and/or low worm challenge. This hypothesis is being addressed but supported by a greater lamb BW gain than that observed in thinner, parasitized ewes grazing parasitologically dirty pastures (Kidane *et al.* 2010). In this experiment, we observed unexpected carry over effects of supplementation during pregnancy on plasma protein levels during eight weeks of lactation. The data unexpectedly showed that DUP supplementation during late pregnancy increased plasma protein (both albumin and globulin) levels during lactation. At face value, this would suggest that ewes not supplemented during late pregnancy would have been in a greater degree of protein scarcity than their supplemented counterparts. This was not reflected in ewe performance, which may have been masked by the presence of body reserved, and puts some doubts on the value of plasma albumin for assessing ewe nutritional status.

2015 HAU Experiment 3: Effect of nutritional restriction in mid-pregnancy and level of protein supply on ewe and lamb performance during late pregnancy and early lactation.

A 2 x 2 factorial experiment was conducted to investigate the effect of nutritional restriction in mid-pregnancy and level of protein supply on ewe and lamb performance. Forty-eight twin-bearing Suffolk x Mule ewes (77.5 kg) were fed straw *ad-libitum* (L) or straw *ad-libitum* plus 0.5 kg/day concentrate (H) from day 70 to 105 of gestation. From day 105 of gestation ewes were housed individually and fed straw *ad-libitum*, together with one of two concentrates formulated to supply either a low (LP) or high (HP) level of protein supply. Both concentrates were formulated to supply similar levels of ME, FME and ERDP. However, concentrate LP was formulated to provide 180 g/kg DM CP and 28 g/kg DM DUP, and concentrate HP was formulated to supply 212 g/kg DM CP and 56 g/kg DM DUP. Diets LP supplied 1.0 and 0.8, whereas diets HP supplied 1.25 and 1.0 of calculated MP requirements during pregnancy and lactation respectively (AFRC, 1993). Nutritional restriction in mid-pregnancy had no significant effect on litter BW, colostrum and milk component yields and litter growth rate between weeks 0 to +4 *post-partum*. However, between week +4 and week +8 *post-partum* lambs on treatment H had a higher litter growth rate than those on treatment L (506 *vs* 450 g/day). Level of protein supply had a significant effect on both ewe and lamb performance. Ewes fed concentrates HP had a higher *pre-partum* BW gain (12.25 *vs* 9.80 kg) and higher litter BW (10.09 vs 9.26 kg) than those fed concentrates LP. Similarly, ewes fed concentrates HP had significantly higher colostrum component (Colostrum yield 3.37 *vs* 2.55 litres/day) and milk component yields (Milk yield 3.22 *vs* 2.97 litres/day) than those offered concentrates LP, which resulted in higher litter growth rates (599 *vs* 520 g/day) throughout the experiment. *Pre-partum* ewes on treatment LHP had the highest BW gain, CS loss, litter BW and colostrum component yields, which suggests that for ewes in poorer condition, additional MP supply *pre-partum* may be beneficial to maximise litter BW and early lamb performance. However, *post-partum* ewes on treatments HHP had the highest BW loss, milk component yields and litter BW gains. The FEC of all ewes was low and constant throughout the experiment, and there was no effect of experimental treatment on FEC or immune status. Overall, the fact that the effects of nutritional restriction on litter growth rate did not become apparent until week +4 *post-partum* highlights the importance of maternal body reserves in maintaining ewe milk yield and lamb growth rate. The observed responses to additional dietary MP supply depend on the interaction between nutrient requirement and maternal body reserves and require further investigation.

2015 SRUC Experiment 3: Interactive effects of worm exposure and DUP supplementation on ewe and lamb performance.

Twin-bearing Dorset-mated Dorset crosses, with mean BW of 59.6±0.8 kg and CS of 3.14±0.05 at day 48, were housed individually and dewormed. Then, half of the ewes were dosed until turnout (day 12) with 10,000 *Teladorsagia circumcincta* larvae every Mon-Wed-Fri (Par) and the other half with water (Sham), whilst feeding *ad-libitum* hay and 100 g/day commercial concentrates (n=24). From day -21 until day 12, ewes were fed at 0.9 times energy requirements (AFRC, 1993) a 30:70 hay:concentrate ration. A 1:1 mixture of xylose-treated rapeseed meal (RaPass®) and soya bean meal (SoyPass®) was used in the concentrates to increase DUP levels from 25 (LP) to 52 (HP) g/kg (n=24). From day 12, ewes grazed one of eight 0.5 ha previously-grazed grass-clover pastures (six ewes and their 12 lambs each), where HP ewes were supplemented with a high DUP pellet (45% RaPass® and 45% SoyPass®) at 400 g/head/day until day 57. Housed ewes were assessed regularly for BW, CS, and serum BOHB. Lambs were weighed at birth and day 12. During grazing, ewes and lamb BW, and ewe CS and faecal egg counts (FEC), were taken on day 36, day 57 and day 105 (weaning). Data were analysed using 2×2 ANOVA, with ewes and plots as experimental units before and after day 12, respectively.

Experimental parasite exposure reduced ewe BW until turn out from 58.1 to 56.2 kg (s.e.d. 0.56 kg; P=0.027) but led to increased ewe BW at weaning from 49.2 to 54.1 kg (s.e.d. 0.87; P=0.089), which coincided with lower FEC in Par ewes than Sham counterparts at day 57 and weaning. This was most likely a reflection of ewes being exposed to natural challenge upon turn out whilst being away from challenge during housing. Treatments did not affect CS, which gradually reduced to 2.30±0.06 at turn out and then increased to 2.91±0.12 at day 105. Both DUP supplementation and parasite exposure increased serum β-hydroxy-butyrate (BHB) at day 12 though levels remained well below 1 mmol/l, indicating no risk for twin lamb disease. DUP supplementation increased periparturient ewe BW throughout supplementation, reaching a maximum effect by day 36 of 54.8 vs 57.9 kg (s.e.d. 0.84 kg; P=0.015) and litter BW at turnout through weaning, though more pronounced for Sham ewes, where litters ended up ~7 kg heavier upon DUP supplementation. The FEC of Par ewes was greater than that of Sham ewes on day 36 (P<0.001), but smaller on day 57 (P<0.001) and day 105 (P=0.071). DUP supplementation reduced Par geometric FEC by ~40% on day 36, but this interaction was directional at best (P=0.130). Parasite exposure increased plasma pepsinogen during housing, but this fell faster during grazing than for the Sham ewes, whose pepsinogen levels increased over time.

This data support the view that in the presence of worm challenge, DUP supplementation may boost ewe performance. The unexpected temporal effects of experimental challenge on ewe BW and FEC indicate that ewes were exposed to natural infection post turnout, and that previous worm exposure may assist a faster return to immunity as lactation progresses.

2015 SAC/SRUC Farm trails: Impact of reduced frequency of DUP supplementation on ewe performance.

Three farm trials were designed to demonstrate that feeding high DUP supplements 3x per week (TW) would not affect ewe performance compared to feeding it daily (D), achieving the same amount of DUP per week. One of the farms dropped out due to high potential acid load (PAL) silage, and was not able to take the risk associated with potentially low silage intakes.

On Farm 1, two groups of 50 twin-bearing ewes were fed a TMR containing Ultrasoy® (formaldehyde protected SBM) as the sole supplement to mineralised silage, fed either once/day at 100 g or 3 times weekly at 227 g per feeding. The silage that was available had an 11.7 MJ ME, 116 g protein, 3.6 pH, dry matter of 287 g/kg, and PAL of 824 meq/kg DM, and was fed *ad libitum*. The silage was from perennial rye grass with 50 g/kg potatoes and some oats. No other supplements were given. Birth weights averaged 4.21 for D lambs and 4.25 kg for TW lambs, which did not differ significantly. Blood samples were checked for BHB, which was 1.17 (range 0.3-4.7) for D ewes and 0.43 (range 0.3-1.0) for TW ewes. The outlier in D ewes was a problematic older ewe. Omitting that data point, it was concluded there was no detrimental impact on BHB levels, which were below threshold for twin lamb disease. Urea and albumin levels were 4.90 mmol/l and 30 g/l for TW ewes, and 4.95 mmol/l and 28 g/l for D ewes. These values did not differ significantly. Subsequent lamb growth appeared normal, though no additional records were taken. The farmer concluded that in future years to save labour and cost she would target producing high quality silage supplemented with only Ultrasoy/Sopralin and mineral and vitamins. The feeding method of adding Ultrasoy/Sopralin to a TMR on 3 days a week vs daily could also save labour. The trial proved the concept that alternate day feeding works when given as a TMR and provided further good evidence for good ewe performance on high quality silage + DUP supplementation.

On Farm 2, two groups of 60 twin-bearing ewes were trough fed Ultrasoy® again as the sole supplement to mineralised silage at same rates as in Farm 1. The silage used was made from perennial ryegrass, cut in June and indicated a DM of 278g/kg, ME content of 11.9 MJ/Kg.DM with a CP of 144g/kg DM. The silage PAL, although high at 854 meq/kg DM, was not considered high enough to cause intake problems on this silage with optimum dry matter content for sheep and a pH of 4.4. Birth weights recorded averaged 5.37 for TW lambs and 5.28 kg for D lambs, which did not differ significantly. Week 8 BW averaged 22.98 and 22.54 kg, respectively, indicating growth rates of 314 and 300 g/day, respectively. Blood samples were checked for BHB, which was 0.67 (range 0.4-1.1) for TW ewes and 0.53 (range 0.4-0.8) for TW ewes. Urea and albumin levels were 7.2 mmol/l and 26.8 g/l for TW ewes, and 7.7 mmol/l and 26 g/l for D ewes. These values did not differ significantly. This trial provided evidence that there were no production penalties from feeding protected soya 3X a week vs daily, however every second day feeding was introduced as it was easier to remember when to feed. The farmers were very enthusiastic about the savings in cost and labour from the new feeding regime compared to previous years when moderate quality silage was supplemented with heavier compound feeding. Further work is needed to make supplementation of soya / protected soya at pasture after lambing easier as feeding in troughs in wet weather caused wastage.

Outputs from the project

Events

1. SAC Sheep Group (Carfaemill), 18 Feb 2015.
2. Society Feed Technologists Ruminant Conference (Coventry), 23 Apr 2015.
3. NorthSheep (Cockermouth), 3 Jun 2015.
4. Field Day, Causeypark Farm (Causeypark), 13 Oct 2015.
5. Feed into Lamb: Ewe nutrition workshop (SRUC, Edinburgh), 4 Feb 2016.
6. SAC Sheep Group (Carfaemill), 7 Mar 2016.
7. Scotsheep (Blyth Bridge), 1 Jun 2016.
8. AHDB Beef & Lamb Sheep Research Day, (HAU, Newport), 19 Jul 2016.
9. AHDB Beef & Lamb Consultants Workshop (Coventry), 13 Sep 2016.

Articles (all by Vipond JE, SAC Consultancy)

1. Sheep feeding needs new nutrition model. Sheep and Beef Producer, Spring 2015, p 20-21.
2. Making the most of protein in ewe feeds. Scottish Farmer, 14 Feb 2016.
3. Practical methods of feeding DUP to sheep. SRUC Farming for a better climate. Mar 2016.
4. Machynlleth sheep farmer saves a small fortune with new feeding regime. Daily Post, 14 Apr 2016.
5. Sheep farmers urged to watch out for acidic silage. Aberdeen Press and Journal, 10 Feb 2015.
6. Improved margins from better feeding of ewes. Grass & Forage Farmer, Winter 2015.
7. Reducing lost profits. Scottish Farmer, 25 Jul 2015, p 16.

Conference papers

1. Houdijk JGM, 2014. Benefit of by-pass based protein supplementation on periparturient ewe performance. Advances in Animal Biosciences 5, 30.
2. Houdijk JGM, Vipond JE, 2014. Home-grown alternatives for by-pass soya bean meal. Advances in Animal Biosciences 5, 17.
3. Houdijk JGM, Smith LA, Vipond JE, 2015. By-pass based protein supplementation and periparturient ewe performance. Advances in Animal Biosciences 6, 162.
4. Houdijk JGM, van der Heiden A, Trienes Y, Vipond JE, 2016. Interactive effects of by-pass protein supplementation and parasitism on ewe performance. Advances in Animal Biosciences 7, 18.
5. Vipond JE, 2015. High quality silage with flat rate supplementary feeding of soya for ewes. Proceedings of the British Grassland Society, Sep 2015.
6. Wilkinson RG, Naylor N, Mackenzie AM, Pattinson SE, Donaldson J, 2014. Effect of forage type and level and source of DUP supply on ewe and lamb performance. Advances in Animal Biosciences 5, 18.
7. Wilkinson RG, Gauld C, Mackenzie AM, Pattinson SE, Donaldson J, 2015. Effect of level and source of protein supply on the performance of ewes during late pregnancy and early lactation. Advances in Animal Biosciences 6, 158.
8. Wilkinson RG, Gauld C, Mackenzie AM, Pattinson SE, Donaldson J, 2015. Relationship between body condition, back-fat and muscle depth in Suffolk x Mule ewes. Advances in Animal Biosciences 6, 163.
9. Wilkinson RG, Naylor N, Mackenzie AM, Pattinson SE, Donaldson J, 2016. Effect of nutritional restriction in mid-pregnancy on the response of ewes to additional protein supply in late-pregnancy and lactation. Advances in Animal Biosciences 7, 17.
10. Wilkinson RG, Houdijk JGM, 2016. Should we feed more metabolisable protein to pregnant and lactating ewes? Advances in Animal Biosciences 7, 164.

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

The MP requirement of ewes increases dramatically in late pregnancy and early lactation due to increasing foetal growth and milk production (AFRC, 1993). Failure to meet these requirements may reduce ewe and lamb performance. Over the last few years, terminal sire schemes and genetic selection for higher productivity has resulted in increased lamb birth weights (Roden *et al.,* 2003; Marquez *et al*., 2012), and higher levels of ewe milk production, with resultant increases in ewe MP requirements. In addition, there is growing evidence that ewes may require additional MP to maintain immunity to parasitic infection (Houdijk *et al*., 2003 & 2009). These issues are compounded by the fact that AFRC, (1993) estimates of the net protein requirement for maintenance are lower than those predicted by other nutritional standards (INRA 1989; NRC 2007 & CSIRO 2007), because they do not include an allowance for metabolic faecal protein, which varies directly with level of feeding. As a consequence, there is growing concern that AFRC (1993) may underestimate MP requirements, and that ewes may respond to additional MP supply above currently recommended levels (Robinson 2001; Cottrill, *et al*., 2009).

In commercial sheep production farmers feed a variety of forages and compound feeds (or blends) to satisfy nutrient requirements. These typically contain 160-180 g/kg CP, with soya bean meal as the main protein source. Both the forage and concentrate components contribute to optimising the rumen ERDP to FME ratio and MP supply. However, depending on the CP and protein degradability characteristics of the forage, the use of a standard concentrate may not maximise MP supply (Wilkinson *et al.,* 2000). In addition, the UK is currently only 30% self-sufficient in vegetable protein sources, with the rest being imported from overseas. Increased reliance on imported vegetable protein, particularly soya bean meal, represents a serious risk to UK agriculture, and there is an urgent need to increase utilisation of home grown protein sources. At the same time, the UK Low Carbon Transition Plan (HM Government, 2009) has set out a strategy to reduce UK greenhouse gas (GHG) emissions by 18% of 2008 levels by 2020, including an 11% reduction from agriculture. The Beef and Sheep Roadmap (AHDB, 2012) indicates that GHG emissions from sheep and beef farms range from 6.43-19.71 kg CO_2^e/kg BW, with farms having the lowest emissions having high levels of ewe and lamb productivity and low reliance on imported protein sources such as soya bean meal, which carries a high environmental burden.

The results of experiments at both HAU and SRUC during 2013 and 2014 suggest that increasing MP supply, especially through DUP supplementation to levels above currently accepted requirements (AFRC 1993) increases ewe BW gain, reduced CS loss and enhances colostrum component yields. However, they were unable to convincingly demonstrate any positive effects in relation to lamb birth weight, lamb performance or subsequent weaning BW. These results are consistent with those reported in the literature, where most authors have reported no effects of additional DUP supply on lamb birth weight and subsequent performance (O' Doherty and Crosby, 1996; Dawson *et al.,* 1999; Annett *et al.*, 2008; Amanlou *et al.,* 2011 and Van Emon *et al.,* 2014), but various benefits in relation to ewe performance. For example, additional DUP during late pregnancy was shown by Van Emon *et al*., (2014) to increase ewe BW gain and reduce CS loss. Similarly, increases in colostrum component yield were reported by O' Doherty and Crosby (1996) and Amanlou *et al.*, (2011). However, in all of these published studies, and those carried out by ourselves, ewes were in good condition when the study commenced. In addition, in our experiments diets were formulated for no BW change, and ewes on all treatments lost condition throughout the experiments. The fact that source of protein supply had no effect on litter birth weight or subsequent performance suggests that when diets are appropriately formulated, home grown protein sources such as rapeseed meal and field beans can be used as alternatives to soya bean meal in ewe diets.

The results suggest that both ME and MP requirements may be higher than currently predicted, AFRC (1993). Metabolisable protein is supplied from both the diet and mobilisation of tissue reserves. Observed responses to additional dietary MP supply may depend on the balance between nutrient requirements, dietary supply, and the capacity of the animal to mobilise nutrients from body tissue. During both pregnancy and lactation, ewe in good condition may mobilise nutrients from tissue reserves to ensure that foetal growth and milk component synthesis are not compromised. Consequently, they may only show a marginal response to additional MP supply (Oldham, 1994; Wilkinson, *et al.,* 2000). When glucose requirements for foetal development or lactose synthesis are high, a proportion of the absorbed amino acids may be deaminated to provide precursors for gluconeogenesis in the liver, with the remainder being used to support protein synthesis. However, energy and protein supply from tissue loss may vary depending on ewe condition, and may only be exploited if tissue loss is not physiologically damaging to the animal. A greater response to additional MP supply may be expected if ewes are in poorer condition (Dawson *et al.,* 1999), or presented with a higher nutritional challenge.

In the 2015 experiments, ewes at the HAU trial were subjected to nutritional restriction in mid-pregnancy, calculated to induce a CS loss of approximately 0.5 units, which is common in commercial practice. The fact that nutritional restriction had no effect on litter weight, colostrum and milk component yields is consistent with accepted guidelines that up to 0.5 units of CS loss in mid pregnancy has no effect on placental development and subsequent lamb performance (MLC, 1988). Similarly, nutritional restriction in mid-pregnancy has no effect on litter gain between week 0 and week +4 *post-partum*. However, the reduction in litter gain between week +4 and week +8 observed in lambs on nutritionally restricted ewes suggests that, although not statistically different, milk component yield was lower in these ewes. This is supported by the fact ewe BW and CS loss was greater, and emphasises the importance of ewe CS and maternal body reserves in maintaining milk yield and lamb growth rate throughout lactation.

Ewes fed high protein diets had higher *pre-partum* BW gains than those fed the low protein diets. In addition, although not significantly different, higher protein supply reduced ewe *pre-partum* condition loss. This suggests that ewes used additional MP to support an increase in the weight of the products of conception, resulting in a higher litter birth weight from ewes fed the high protein diets. In addition, ewes fed the higher protein diets had higher colostrum and milk component yields, which resulted in increased litter gain throughout the experiment. However, there was no effect of level of protein supply on ewe *post-partum* BW or CS change or metabolic status. Consequently, the mechanism responsible for the observed increases in ewe performance is unclear.

Throughout the experiment no significant interaction between nutritional restriction in mid pregnancy and level of protein supply were observed. However, there were clear numerical differences. The coefficient of variation (CV %) for some of the variables measured was high, and more replicates per treatment may have been required. *Pre-partum*, ewes which had undergone nutritional restriction on the high protein diet (LHP) had the highest BW gains. They also had the highest litter BW and colostrum component yields. This suggests that for ewes in poor condition, additional MP supply *pre-partum* may be beneficial to maximise litter BW and lamb performance in early lactation. However, *post-partum*, ewes which had not undergone nutritional restriction on the high protein diet (HHP) had the highest BW loss and milk component yields, which resulted in the highest litter gains. As expected, nutritionally restricted ewes on the low protein diet had the lowest litter weights, colostrum and milk component yields, and litter BW gains. Throughout the experiment, the response of ewes to additional MP supply was highest in ewes subjected to nutritional restriction. However the exact mechanism is unclear. It is often the case that ewes that have never experienced nutritional restriction produce ‘average’ lambs (Vipond, 2016. Personal communication). A period of nutritional restriction may be beneficial in priming metabolic processes to maximise the efficiency of nutrient utilisation, in a similar manner to compensatory growth. During lactation, responses to additional dietary MP supply may depend on the balance between nutrient requirements and the capacity of the animal to mobilise nutrients from body reserves. Although the effects of additional MP supply on litter gain were evident from birth, the effects of nutritional restriction did not become apparent until week +4, suggesting that the availability of energy reserves may influence the response to additional MP supply. For example, additional energy may be required to optimise nutrient utilisation in ewes fed additional MP. This may be available from fat, but not thin ewes, as reported in dairy cows (Garnsworthy and Jones 1987; Jones and Garnsworthy, 1988). However, this mechanism can only be exploited if body tissue loss is not physiologically detrimental to the animal.

In the 2015 SRUC trial, it was observed that the largest response to DUP supplementation came from ewes that were exposed to worm challenge, although this was only observed at turn out. This contrasts with our expectation that ewes would respond during experimental challenge as well, and reflects commercial practice where ewes are removed from parasitic challenge during housing, and then return to challenge upon turn out. As such, the outcome of this experiment should increase producer confidence in the benefits of DUP supplementation. In this case a mixture of protected soya and rapeseed meal reduced soya input and increased lamb growth rates, adding an extra 2.5 to 3 kg BW to their lambs at weaning.

The following key messages can be obtained from the farm trials conducted. Compound feeds with either 160 or 180 g/kg crude protein may not satisfy the MP requirements of ewes and under certain situations additional DUP supply may increase lamb birth and weaning BW. However, the series of AHDB trials at HAU and SRUC showed considerable variation in response to DUP due to ewe condition and parasitism. Consequently, it may be worthwhile targeting DUP supplementation to thin ewes and those on wormy pastures. Some of the variation in response to DUP may be due to interactions between the starchy components of supplements and high quality forages affecting microbial protein supply. This may explain why additions of DUP to high quality forage work well in practice on commercial farms. Trials have looked at a range of protein sources with evidence of better response to soya and protected soya. Rapeseed meal may also have a role although there could be palatability issues at high inclusion rates, prairie meal has high DUP levels but a poorer amino acid balance. Soya however has a poor environmental footprint and we should strive to use as little as possible. By using protected protein we can halve the amount of soya fed where all we want to add is DUP, for example on silage based diets. Further work is needed on manipulation of amino acid supply made possible by DUP supplementation. Arginine, which is high in soya, may act not only as a building block for protein but also as a precursor for opening new metabolic pathways important to lamb survival. The farm trials suggest that daily supplementation of high quality forages with additional DUP may not be necessary, and that lamb birth and weaning BW can be maintained by moving to supplementation every other day, with considerable savings in labour costs. In addition, moving away from high levels of concentrate supplementation has many advantages. Variation in intake when feeding cereals can risk sub clinical acidosis and consequent reduction in microbial protein supply. Less food to handle, releases time for lambing management and welfare of lambs. Reduced labour and costs will be welcomed by the sheep industry but challenging for the feed supply sector which needs to be taken along with the development of new and better products. However, many farmers will be unable to produce a high quality silage required so there is certainly still a role for traditional compounds. The challenge is to feed ewes so they do not get stressed pre lambing or their grazing disturbed post lambing, here soya and protected soya is better as an ingredient in a TMR than whole cereals, which cause selection, leading to aggression and may have role in lamb mortality.

We need to take all this information forward within a supplementation policy which targets not the traditional approach of meeting theoretical energy needs but on an approach that is centred on achieving successful outcomes of more live lambs.

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

The results of the work carried out indicate the following:

1. (HAU) In all three experiments, diets were formulated to satisfy the ME requirements of ewes using AFRC (1993) recommendations, assuming no BW change during both pregnancy and lactation. However, all ewes lost condition suggesting that ME requirements may be higher than predicted. A number of factors may have contributed to this, including the fact that lamb birth weights were higher than those assumed by AFRC (1993).
2. (HAU) With ewes in good condition (CS>3.0) additional MP supply above accepted ARFC (1993) requirements has no effect on lamb birth weight or subsequent weaning BW. However, when demand for glucose is high, ewes may show a marginal response to increased MP supply (0.20). This may reduce ewe condition loss and increase colostrum component yield.
3. (HAU) Protein source has no effect on lamb birth weight or subsequent lamb performance suggesting that alternative home grown protein sources such as rapeseed meal, and perhaps to a lesser extent field beans, can effectively replace soya bean meal in ewe diets.
4. (HAU) The fact that moderate nutritional restriction in mid-pregnancy had no effect on lamb birth weight and early lamb performance is consistent with current recommendations (MLC 1988). However, the resultant reduction in CS and tissue reserves may compromise milk component yield and lamb growth in later lactation.
5. (HAU) For ewes in poor condition (CS<2.5) or those having experienced nutritional restriction, additional MP supply above AFRC (1993) requirements *pre-partum* increases may be beneficial to maximise lamb birth weight, colostrum and milk component yields, and subsequent lamb performance. Nutritional restriction may be beneficial in priming metabolic processes to maximise the efficiency of nutrient utilisation.
6. (HAU) In all three experiments the high level of MP supply *post-partum* was 100% of AFRC (1993) requirements. The response of ewes to additional MP supply depends on the availability of energy. When energy reserves are depleted and ewes are in poor condition (CS<2.0) a marginal response (0.2) to additional MP supply may be obtained. However, a greater response is likely from ewes with higher tissue reserves. Additional energy may be required to optimise nutrient utilisation in ewes fed additional MP.
7. (SRUC) When ewes are in a good condition (>2.5) and virtually worm free, DUP supplementation may only temporarily increase ewe BW but is unlikely to result in improved lamb BW gain.
8. (SRUC) Despite an absence of a carry over effect of DUP supplementation during late pregnancy on ewe performance, blood samples showed a carry over effect on plasma albumin, indicating that the latter may not always reflect ewe nutritional status.
9. (SRUC) In the presence of an active worm challenge, the response of ewes to DUP supplementation on lamb performance is more pronounced. In the Year 3 trial, this was not the case for ewes not challenged during housing. This novel observation suggests that it may be beneficial for ewes to always have some level of parasite exposure, even during housing, to maintain an active immune system.
10. (SRUC) In support of observation 6 above, DUP supplementation increased plasma BHB levels, which may indicate that body reserves were mobilised to utilise protein arising from restricted energy feeding. At the same time, it was observed that exposure to incoming larvae increased plasma BHB, may have resulted from fat mobilisation to fuel pathophysiological responses.
11. (SRUC Farm trials) Making use of the expectation that protected protein should not affect rumen metabolism, at least to the same extent as rumen degradable protein, two independent farm trials demonstrated that daily feeding of protected soya resulted in the same ewe performance as 3x per week supplementation. This attribute of DUP supplementation provides farmers with an opportunity to reduce labour costs.

Q6: Gaps in knowledge – what gaps in knowledge did this project identify?

The results of the work carried out suggest the following gaps in knowledge:

1. (HAU) In all three experiments, diets were formulated to satisfy the ME requirements of ewes using AFRC (1993) recommendations, assuming no BW change during both pregnancy and lactation. However, all ewes lost condition suggesting that ME requirements may be higher than predicted. Further work is required to re-evaluate the ME requirements of pregnant and lactating ewes.
2. (HAU) The response of ewes to additional MP supply depends on the complex interaction between energy and protein supply from both the diet, and from mobilisation of tissue reserves. However, energy and protein supply from tissue reserves may depend on physiological state, CS and previous nutrition and may only be exploited if tissue loss is not physiologically damaging to the animal. Further work is required to better understand the relationship between CS loss and nutrient supply.
3. (HAU and SRUC) The conclusions drawn from the current work are derived from relatively small scale intensive experiments using Suffolk x Mule ewes at HAU throughout and Texel x Mule ewes at SRUC Years 1 and 2, and Dorset x Dorset crosses at SRUC Year 3. Further work is required to test outcomes in larger scale commercial practice.
4. (SRUC) It remains unclear whether carry over effects from late pregnancy into lactation may reduce the need to develop supplementation strategies post turn out. Experiment 2 failed to observe this, although subsequent work suggests that this may have been due to complex interactions between other drivers of protein scarcity (worm challenge, body reserves, protein quality).
5. (SRUC) All the calculations underlying the results presented were based on published assumptions for protein protection, ruminal degradation and microbial protein synthesis, with associated errors. Detailed rumen degradability and microbial protein synthesis studies on novel protected protein sources would facilitate better interpretation of the results obtained.
6. (SRUC) In contrast to previous work at SRUC, increased DUP supply failed to reduce worm egg excretion when ewes were naturally carrying a worm burden. This indicates that additional protein may only reduce faecal egg counts during active challenge, which would agree with the long held view that incoming larvae rather than adult worm burdens limit productivity.
7. (SRUC) All trials suggest that responses to additional DUP supplementation on ewe performance may have been limited by energy availability, arising from the restricted feeding. Greater responses to DUP supplementation may be obtained when it coincides with an increase in energy supply, either from increased fibre intake (starch and sugars may be too risky for acidosis) or protected fat.
8. (SRUC Farm trials) The excellent results from feeding high quality silage with protected soya only suggest that tailor made silage may be a novel way to reduce reliance on traditional concentrates. It might be tested whether different types of silages or addition of protected soya during the ensilage process results in an ensilaged TMR product that does not require any supplements to obtain satisfactory production, and what level of protected protein should be added to high ME silage to meet ewe MP requirements.

Q7: Cost:benefit – what is value of this project?

One of the most regular questions farmers ask when they hear about responses to DUP supplementation on ewe performance is what the cost-benefit implications would be. From this project, we can extract some data that can help to address this important issue. As presented above, only Year 3 ewe trials at both HAU and SRUC showed that additional DUP supply increased lamb weaning BW. In experiment 3 at HAU lamb performance were greatest from ewes that that had experienced nutritional restriction during mid pregnancy. In experiment 3 at SRUC lamb performance was greatest from ewes exposed to worms upon turn out only (unexpectedly in contrast to ewes experimentally exposed to worm challenge during housing). Therefore, for the cost-benefit analysis approached below, this sub-set of data has been used.

The benefits of an increased lamb BW gain need to be compared against the costs of additional DUP supplementation. The financial benefits would arise from reduced lamb losses, an accelerated finishing, which often attracts greater lamb prices and reduced grazing days for lambs, which frees up forage for other purposes. The costs would arise from the additional costs of high DUP concentrates or purchase and feeding of straights providing similar levels of DUP. In this estimation of the cost-benefit, the latter has been approached by estimating the monetary value of the protected SBM equivalent of the extra DUP fed, relative to the non-supplemented counterparts.

The HAU study indicated an additional lamb BW of 3.06 kg at weaning for each of the twin lambs from an extra input of 2580 g DUP per ewe. For the SRUC studies, these figures were 2.66 kg at weaning for each of the twin lambs from an extra input of 3092 g DUP per ewe. Assuming that protected SBM (Sopralin®) contains DUP at 282 g/kg (Hazzledine, 2008), and costs £440/tonne delivered (March 2016, Vipond, personal communications), this means an extra costs of £4.02 per ewe for HAU and £4.82 per ewe for SRUC. Assuming drawing at 42 kg BW, and that BW differences at weaning remain until drawing, the heavier lambs at weaning translate to a reduction in grazing of 14 days for HAU (assuming 225 g/day post weaning growth) and 11 days for SRUC (measured 239 g/day post weaning growth to realized drawing). Assuming that for Autumn lambs this ~14 days accelerated finishing could result in an increase in price by 15p per kg dwt, and at a killing out percentage of 45%, then this would have provided a return of £5.70 per ewe for her twin lambs. Further assuming that grazing costs £1 per head per week (Vipond, personal communications), the reduced grazing reduces costs at £3.89 for HAU and £3.29 for SRUC brings a net benefit ranging from £5.56 for HAU data and £4.17 for SRUC data. These calculations, and thus the net benefit, are sensitive to prices, and will greatly depend on the cost of supplements and the seasonal variations in lamb price. A larger data set, however, would be needed to also factor in whether, and to what extend DUP supplementation affects lamb survival. Both trials used here were too small to provide meaningful data on that; if DUP supplementation increases lamb survival, which is expected, then the margins would increase considerably.

The other cost benefit comes from cost savings during housing, as observed during the farm trials. Whilst feeding protected SBM 3 x per week rather than weekly at same weekly rates will not affect costs of supplements used, the labour saving is significant, and both farmers considered that a great benefit of this approach, though difficult to quantify in monetary terms. Both farmers, however, replaced the traditional feeding of concentrates and silage with feeding soya and vit/min only whilst offering 11 ME+ silages. This resulted in a cost saving of £2.25 per ewe between 2014 and 2015 on one of the farms, whilst performance was similar if not better. Provided that high ME silage is available, the savings in time, cost and labour through supplementing with protected soya only can offer big savings to farmers over conventional approaches where farmers often overfeed rumen degradable protein. As an example of the savings in feed and labour a Northumberland farmer who attended both the AHDB field day at Causeypark and the SRUC ewe nutrition workshop, saved £9.87/ewe over previous years costs by supplementing an average silage with soya + sugar beet. In addition to saving £12,000, time saved on mixing feed was 1.5 h/day and prolapses reduced from an average of 15-20/year to 1. This work has been invaluable in giving the confidence to obtain funding from KTIF and H2020 to target reducing UK lamb mortality by 5% by integrating its findings with other best practices.

Q8: Additional deliverables – what activity is planned with the results from this project?

Activity	What is planned?	When likely to happen?
Events	AHDB (Beef & Lamb) Consultants Workshop (Coventry).	13th September 2016
Press articles	Articles in the farming press.	2016 – 2018
Conference presentations, papers or posters		
Scientific papers	It is anticipated that 2-3 refereed papers will arise from work conducted at HAU, and 2 refereed papers from the work conducted at SRUC.	2016 – 2018
Other	Presentations to farmer discussion groups	2016 – 2018
Other	Inclusion of outcomes in learning material for students in agriculture	2017