Animal & Grassland Research and Innovation Programme

Teagasc

National Sheep Conference 2015

Sheep Technology Adoption Programme Approved (STAP)

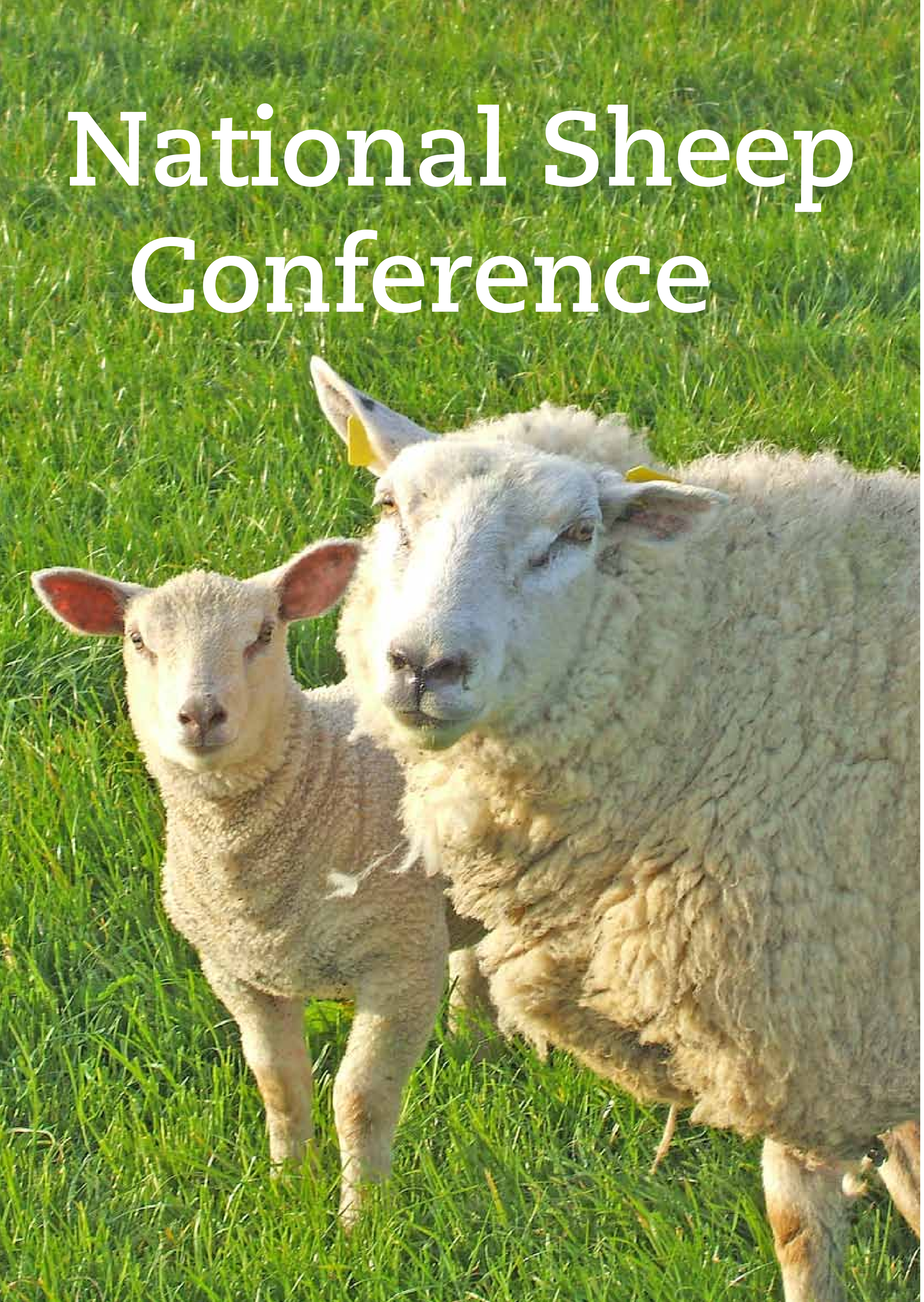
The Malton Hotel,
Killarney, Co. Kerry
Tuesday 3rd February 2015
&
Knightsbrook Hotel,
Trim, Co. Meath
Wednesday 4th February 2015

MSD

Teagasc
Agriculture and Food Development Authority

Mullinahone Co-op

National Sheep Conference



Teagasc National Sheep Conferences 2015
Programme

Venue: The Malton Hotel, Killarney, Co. Kerry

Date: Tuesday 3rd February 2015.

Conference Outline

15.00	Conference Opening Dr Tom Kelly, Director of Knowledge Transfer, Teagasc.
Session I Chairman	**Nutrition** Frank Hynes, Teagasc, Athenry, Co. Galway.
15.10 – 15.40	Making the most of grazed grass *Dr. Phil Creighton, Teagasc, Athenry, Co. Galway.*
15.40 – 16.10	Late pregnancy nutrition of the ewe *Michael Gottstein, Teagasc, Macroom, Co. Cork*
16.10 – 16.50	Worm control strategies with reduced reliance on anthelmintics *Dr Jos Houdijk, Scottish Rural College, Edinburgh, Scotland.*
16.50 – 17.30	Break – Tea/Coffee, Sandwiches & finger food served
Session II Chairman	**Flock Health** Mr. Fergal Morris, Director Ruminant Business Unit, MSD
17.30 – 18.10	Breeding to reduce lambing difficulty and improve lamb survival – a win-win opportunity *Dr. Joanne Conington, Scottish Rural College, Edinburgh, Scotland.*
18.10 – 18.40	**Biosecurity for the Irish sheep flock** *Prof. Michael Doherty, School of Veterinary Medicine, University College Dublin*
18.40 – 19.10	Lameness in Sheep *Dr. Fiona Lovatt, Vet Consultant, UK*
19.10 – 19.20	Close Conference: Prof Michael Diskin, Teagasc, Athenry, Co. Galway

Organising Committee: Michael Diskin, Philip Creighton, Frank Hynes, Michael Gottstein, Ciaran Lynch & Shane McHugh

Teagasc National Sheep Conferences 2015
Programme

Venue: Knightsbrook Hotel, Trim, Co. Meath

Date: Wednesday 4th February 2015.

Conference Outline

15.00	Conference Opening
	Prof Gerry Boyle, Director of Teagasc.
Session I	**Nutrition**
Chairman	Ciaran Lynch, Teagasc, Athenry, Co. Galway.
15.10 – 15.40	Making the most of grazed grass *Dr. Phil Creighton,*
15.40 – 16.10	Late pregnancy nutrition of the ewe *Edward Egan, Teagasc, Navan, Co. Meath.*
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Foreword

Sheep production is a significant contributor to the agricultural and national economy with an output valued at €314 million in 2014. The 33,000 flocks produce a high quality product, with about 75-80% of this exported. Significant employment is provided in both the primary production and processing sectors. The current welcome improvement in lamb prices combined with reduced feed costs and, a reduced supply of New Zealand and Australian lamb, would all suggest that 2015 should be a good year for the sheep industry. However, there is no room for complacency. Technical performance in terms of ewe productivity, grassland management, stocking rate and flock health are all important drivers of profitability and must be the sustained focus of all sheep producers.

In the Teagasc 2013 National Farm Survey an average gross margin of €529/ha for lowland mid-season lambing flocks was achieved. However, the top one third of flocks generated a gross margin of €896/ha compared to €187 for the bottom one third of flocks. Ten per cent of sheep flocks generated a gross margin of >€1000. However, only 8% of flocks reared >1.6 lambs/ ewe to the ram. This indicates that there is significant scope to increase income by improving technical efficiency on many farms. This is also evident from the significant productivity and gross margin gains achieved on the Teagasc Research and Demonstration Flock in Athenry and on the Teagasc BETTER Sheep Farms. Modest improvements in a number of key technologies have very significant impacts on productivity and profitability. I would strongly encourage sheep producers and Discussion Groups to visit the Teagasc BETTER farms. Active participation in such Discussion Groups has been shown to be a most effective way of getting new technology adopted on farms which subsequently translates into increased productivity and increased farm income.

Teagasc is strongly committed to its sheep research and advisory programmes. The expanded BETTER Sheep Farm Programme, the commencement of new studies on genomic selection, in conjunction with Sheep Ireland, mineral nutrition, meat quality are relevant to all sheep producers. Teagasc is also committed to recruit further research staff to its programme in Athenry. The increased collaboration between Teagasc, UCD, Department of Agriculture Food and The Marine and Sheep Ireland as well as overseas collaborators will be of direct benefit the sheep industry.

This is now the 3rd year of the Teagasc National Sheep Conferences and they play a very important role in technology transfer to the sheep industry. I thank all of the speakers who contributed both oral and written presentations and to you the attendance. The sponsorship of MSD Animal Health and Mullinahone Co-op is greatly appreciated. This booklet collates and summarises a significant body of knowledge on technical issues in sheep production and should prove an invaluable reference to sheep producers. I would like to thank all the Teagasc Staff who assisted with the organisation of the National Sheep Conferences and especially the organising committee without whose efforts we would not be here today – they are; Michael Diskin, Frank Hynes, Phil Creighton, Shane McHugh, Ciaran Lynch and Michael Gottstein. I also acknowledge the help of local Teagasc staff particularly of John Donworth and Larry O'Loughlin and their staff.

Director, Teagasc.

Table of Content

Making the most of grazed grass

Philip Creighton

Grassland Science Research Department,

Teagasc, Athenry, Co Galway.

Ireland's strength in sheep production lies in its ability to produce meat from an almost entirely grass based diet thus giving us a competitive advantage over many of our EU competitors. The main challenge for pasture based systems of sheep production is to improve the utilization of pasture and increase the output of lamb from grassland. Higher stocking rates and consequent higher output is possible by increasing herbage yield through greater and/or more efficient use of nitrogen (chemical fertilizer or fixed nitrogen) and by achieving better utilization of herbage in pastures. With grass making up 90-95% of the annual energy requirements of sheep (Davies and Penning 1996), any improvement in the efficiency of production and utilization greatly increase profitability.

Before we can improve and develop our sheep grassland systems we must first look at where we currently are as an industry and where we might like to go to. Table 1 shows the current national average figures for ewe weaning rate, ewe stocking rate/ha, carcass output/ha as well as input levels currently used to achieve this (Teagasc 2014). Also presented are high performance targets that based on previous research work are deemed to be achievable targets (Teagasc 2013).

Table 1. Current national average figures and high performance targets for some of the key performance indicators in Irish mid-season lamb production systems

	National average	High performance target
Stocking rate (ewes/ha)	7.4	13
Lambs weaned/ewe	1.3	1.8
Carcass output/ha	189	460
Nitrogen used (kg/ha)	73.5	159
Concentrates fed (kg/ewe)	50	30

With these figures in mind a long term study investigating the effect of stocking rate and ewe prolificacy potential within Irish grass based systems of sheep production was established on the Athenry Sheep Research Demonstration farm in late 2011. In this study there are three different stocking rates of 10, 12 and 14 ewes/ha. There are two levels of prolificacy, a medium prolificacy system aiming to wean 1.5 lambs/ewe and a high prolificacy system aiming to wean 1.8 lambs/ewe. Valuable information is being gathered across these contrasting systems on:

- grass supply and demand
- drafting patterns
- Carcass output from grass per unit area - the main output from lowland sheep systems.

Taking the whole system into account detailed economic assessments are being made to quantify system profitability and sustainability. The overall objective of this study is to assess the biological and economic efficiency of six grass-based systems of sheep production differing in overall stocking rate and lamb output.

Now in its fourth year, data presented today includes results from the first three years of the study (2012, 2013 and 2014). This information provides indicators as to what can be expected with regard to system output and profitability and the level of grass production and utilisation required to support such systems. While presented for your information it must be remembered that this study is on-going, further data will be added before full analysis and definitive conclusions will be drawn.

What have we learned so far?

Results presented in the following tables highlight some of the key performance indicators with regard to individual lamb performance, overall system efficiency and output. It is worth noting that this is a research study aimed at pushing the boundaries with regard to what is achievable when it comes to finishing lamb from a grass based diet in the most efficient and economic manner.

Table 2 shows the effect of stocking rate and ewe prolificacy potential on lamb performance in terms of growth rate in grams/day pre and post weaning. Also presented is lamb weaning weight at 14 weeks of age.

Table 2. Effect of stocking rate and ewe prolificacy potential on lamb performance pre and post weaning.

	Pre wean (g/day)	Wean wt (kg)	Post wean (g/day)
10 ewe/ha	268	31.2	173
12 ewe/ha	248	29.1	167
14 ewe/ha	246	29.0	161
MP	259	30.6	163
HP	248	28.8	171

MP= Medium prolificacy potential, HP= High prolificacy potential

As we can see increasing stocking rate and prolificacy level does decrease individual animal performance.

Table 3 outlines the drafting pattern of the lambs as affected by treatment. Again we can see that as a result

Table 3. Effect of stocking rate and ewe prolificacy potential on lamb drafting pattern.

	Lambs Drafted by 1st October (%)	Lambs finished on Grass only (%)
10 ewe/ha	80	97
12 ewe/ha	66	93
14 ewe/ha	58	81
MP	68	90
HP	67	90

of lower individual animal performance lambs are slower to finish as you increase stocking rate and prolificacy level. It is worth noting however that over 90% of lambs were finished from grass only with no concentrate supplementation with the exception of the lambs from the highest stocking rate level. The important question then, is whether the reduced individual animal performance figures associated with the increased stocking rate and prolificacy levels is compensated for by a greater increase in output per unit area and ultimately an increase in gross margin.

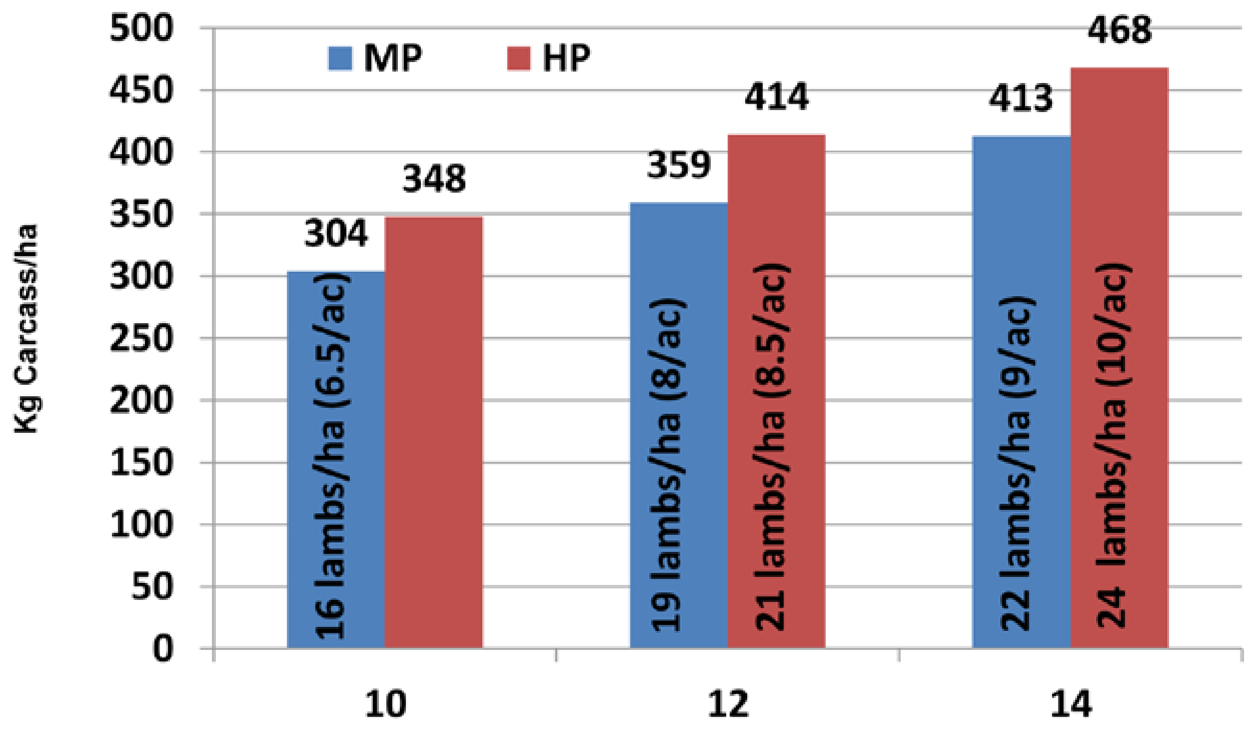

Figure 1. Effect of Stocking rate and ewe prolificacy potential on output/ha.

Figure 1 shows the effect of increasing stocking rate and prolificacy level on output. On average each 2 ewe/ha increase in stocking rate resulted in an increase in output of 58kg of lamb carcass/ha. Increasing the prolificacy of the flock, which in this case was an extra 0.2 lambs weaned per ewe, resulted in an extra 51kg of lamb carcass finished/ha on average. The combined effect of increasing ewe stocking rate by 2 ewes/ha and increasing the number of lambs weaned per ewe by 0.2 is an increase in total output/ha of 109 kg lamb carcass/ha.

The gross margin/ha figures for the different systems are presented in figure 2. Increasing stocking rate by 2 ewes per ha increased gross margin by an average of €55/ha. Increasing the number of lambs weaned per ewe by 0.2 resulted in an average increase in gross margin/ha of €166. The higher return in terms of gross margin/ha observed by increasing the prolificacy of the flock over stocking rate is due to the fact that the cost of maintaining the ewe for the year can be diluted by the extra lamb (0.2) produced. On a whole, increasing stocking rate by 2 ewes/ha and increasing prolificacy by 0.2 lambs per ewe resulted in an average increase in gross margin/ha of €221.

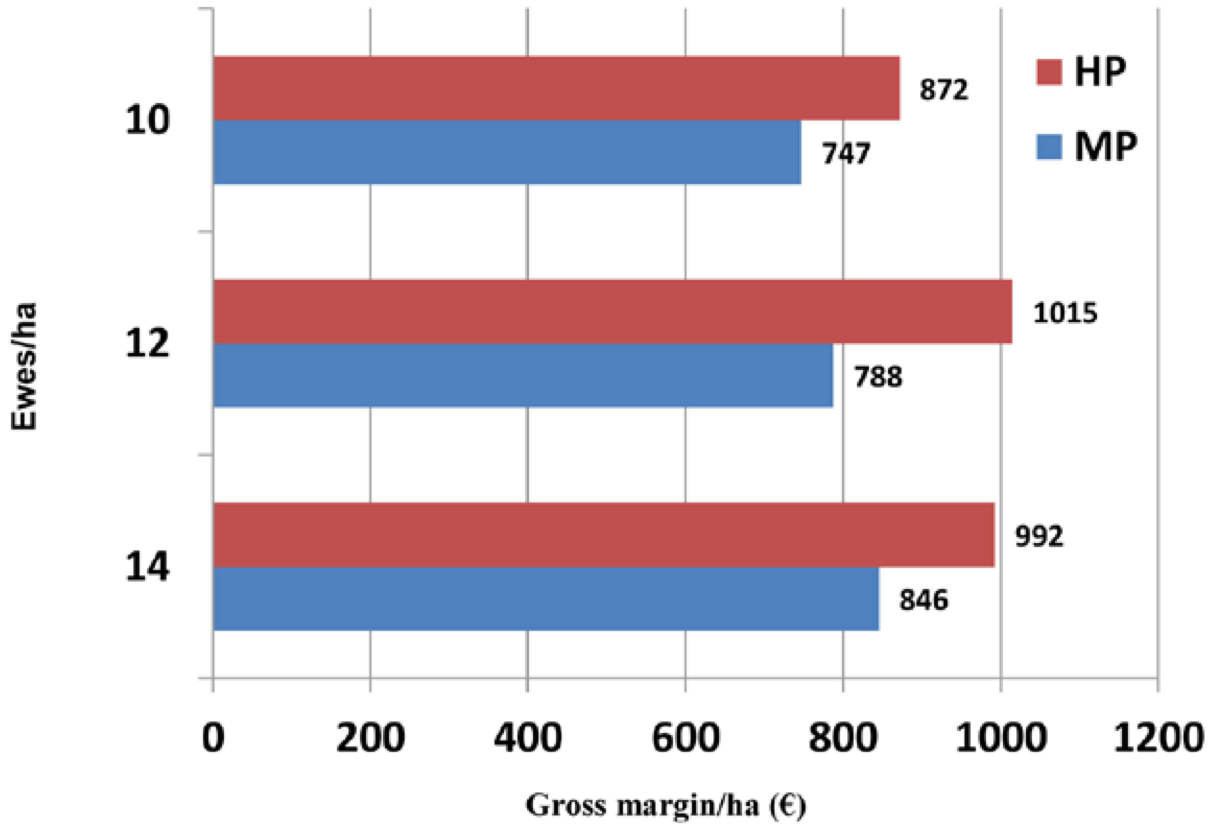

Figure 2. Effect of stocking rate and ewe prolificacy potential on gross margin/ha (€).

The aim of this study is not to come up with an ideal stocking rate and prolificacy level that every sheep farmer should follow, the aim is to maximise the utilisation of grass to maximise an efficient, profitable output of lamb. The optimal stocking rate for individual farms is dictated by the grass growing potential of that farm i.e stock the farm to maximise utilisation of what grass can be grown. Table 4 shows the average grass utilisation levels for the systems and what it means in terms of grass utilised/ewe, per kg of lamb carcase produced and the level of additional supplement (either concentrates or additional forage) required to support the systems. As stocking rate increased the amount of grass utilised/ha increased but decreased on a per ewe basis. This difference per ewe was somewhat explained by an increase in the quantity of additional supplement required per kilogram of total lamb carcass produced. Interestingly the quantity of grass utilised/ha and per ewe was the same in the medium and high prolificacy groups. On average the high prolificacy potential groups weaned 0.2 more lambs/ewe (1.76 v 1.56) which represents a 12% increase in lamb output per ewe. The high prolificacy potential ewes also had a 7kg lower body weight compared to the medium prolificacy potential ewes.

Table 4. **Effect of stocking rate and ewe prolificacy on grass utilised per hectare, per ewe and per kg of carcass output**

	Stocking Rate			Prolificacy	
Variable	Low	Medium	High	Medium	High
Grass Utilised(Kg DM/ha)	9071	10141	11560	10224	10232
Kg Grass DM utilised per ewe	907	845	826	856	857
Kg grass DM utilised per kg carcass	28.0	26.4	26.3	26.2	25.0
Kg supplement required/kg carcass	0.85	1.96	6.20	2.83	2.86

It would appear that the higher feed demands of a greater number of lambs in the high prolificacy flocks was cancelled out by a higher maintenance requirement of the heavier medium prolificacy potential ewes. On an efficiency basis taking into account the total kilograms of lamb live weight weaned per kilogram of ewe live weight mating, the high prolificacy potential ewes were found to be 6.5% more efficient (Earle 2015). This is in agreement with work by Hanrahan 2010.

How was this achieved?

Details of the management targets and inputs for the systems described are presented in table 5. Following lambing ewes and their lambs are turned out to grass and managed in a 5 paddock rotational grazing system. These five paddocks can be sub-divided depending on grass supply and demand into ten grazing divisions to give greater flexibility and control over grass quality offered. Weekly grass budgeting is key to maintaining high quality leafy swards with surpluses removed as baled silage as they arise. This maximises the quality of grass available for grazing while also banking high quality winter feed to be fed back to ewes during the winter (winter feed management of ewes is detailed in the paper 'Late pregnancy nutrition of the ewe' by Egan and Gottstein, these conference proceedings) . Sheep are moved once their target grazing residuals are met. Average residency time in paddocks in April, May and June is 5 days. Post weaning a leader follower system is practiced with lambs having first access to grass, and the dry ewes grazing out paddocks once the lambs had grazed to their target post grazing height. Average residency time in paddocks is 5 days for each group, (5 days for lambs and 5 days for ewes). The paddocks are always subdivided at this time so sheep are moving every 2-3 days. This keeps fresh grass in front of lambs and allows the ewes clean out residuals quickly to allow grass to begin growing again. This form of grassland management maximizes grass growth and utilization while maintaining animal performance as quality is more easily controlled. Rotation length is extended in the shoulder periods of spring and autumn to allow for lower grass growth rates with an average residency time of 8 days in March/early April (First rotation 40 days) and 10 days in Autumn (last rotation 50 days).

When talking about grassland systems of sheep production it must be bourn in mind that grass is a crop like any other. Grazing management/infrastructure, soil fertility and the make up of the swards present i.e. perennial ryegrass content are all critical factors which will influence the success or failure of grassland production systems. Greater detail on the importance of each of these components was presented in a paper to this conference in 2013 (Creighton 2013).

If we are to improve our management and use of grazed grass for sheep systems and begin to make use of the information as detailed in the tables above then as an industry we need to embrace grass measurement and budgeting. There are a number of methods that can be used to measure grass supply on farms. The use of rising plate meters, sward sticks, the quadrant and shears method or simply eyeballing swards and assigning an estimate are all common. What method you use is irrelevant, the important thing is that some form of measurement is carried out on a regular basis which can be used to aid management decisions and build information with regard to the grass growing potential of a particular farm. The trials detailed earlier were not set up to come up with one answer that everyone should follow. Every farm is different. What we can do is use the information gathered to inform decisions with regard to what that farm can potentially achieve. To try and manage any business without knowing what the current and projected future basic inputs may be would not be accepted by the majority and farming and grassland management is no different.

Table 5. Grazing and input targets for stocking rate x prolificacy trial Research Demonstration farm Athenry

	10 ewes/ha	12 ewes/ha	14 ewes/ha
Target pre graze herbage mass (Kg DM/ha)	1200-1500 (7-9cm)	1200-1500 (7-9cm)	1200-1500 (7-9cm)
Target post graze sward height (cm) pre weaning	4.55	4.15	3.75
Target post graze sward height (cm) post weaning	5.5 (lambs) 4.5 (ewes)	5.1 (lambs) 4.1 (ewes)	4.7 (lambs) 3.7 (ewes)
N (kg/ha)	130 (13kg/ ewe)	156 (13kg/ ewe)	182 (13kg/ ewe)
Concentrate (kg/ewe)	30	30	30

A tool which can be used to aid the management and measurement of grass is the 'Grass wedge' concept. The idea of the grass wedge is that once a week the farm is walked and an assessment of the quantity of grass available on each paddock is made be it in terms of kg DM/ha or sward height. You arrange the paddocks from highest to lowest as shown

in Figure 3. A line is then drawn from the point on the graph representing the target pre grazing yield down as far as the point on the graph representing the target post grazing yield. If paddocks are above the line you are in surplus or below the line in deficit. Where there is too much grass available the quality can deteriorate rapidly and on the other end of the scale if we continue to graze swards overly tight for a prolonged period in an effort to improve quality, growth rates can be reduced and we can run short of grass. The idea of the wedge is that we can recognise in advance what is coming down the line and take corrective action. Three words to remember when dealing with grassland systems are Monitor, Manage and Control. The use of the Grass wedge allows us to monitor what is happening allowing us to manage the system to control the desired outcome. Examples of actions which might be taken include removing heavy paddocks as baled silage to reduce supply or increasing fertiliser use where we see a period of deficit emerging.

Figure 3. Example of Grass wedge showing grass surplus

Summary/Key points

- Stocking rate and <u>prolificacy</u> both key drivers of output
  - +109kg carcass/ha (5.5 lambs), +€21/ha GM
  - May be a limit to profitable increases in output
- Majority of lambs can be finished on grass only diet
  - Economics-concentrates up to 4 times the cost of grass
- To succeed, productive swards and good management needed
  - Fencing, soil fertility, reseeding
- Every farm is different
  - Need to know grass production potential of your farm

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Late pregnancy nutrition of the ewe

Edward Egan[1] and Michael Gottstein[2]

[1]Teagasc, Navan, Co. Meath [2]Teagasc, Macroom, Co. Cork

Approximately 70% of foetal growth occurs during the final six weeks of pregnancy (MLC, 1983). Providing the ewe with a balanced diet in late pregnancy is key to:

1) Achieving optimum birth weights.
2) Ensuring a plentiful supply of high quality colostrum.
3) Reducing the risk of disorders like pregnancy toxaemia.
4) Keeping ewes on target for body condition.

A balanced diet must meet the energy, protein, mineral and vitamin requirements of the ewe and facilitate proper rumen function, thereby, maximising intake and reducing the risk of acidosis and prolapse. Ewes carrying twin, triplets or greater are challenged in late pregnancy due to the rapidly increasing size of the foetus and the impact that this has on rumen size.

Energy requirements in late pregnancy

The ewe's requirement for energy increases rapidly in the last six weeks of pregnancy as shown in Table 1. This increased energy demand is required to facilitate the rapidly growing foetus, udder development and in the later stages for colostrum production.

Table 1. Energy requirements (UFL/day) for twin bearing ewe assuming a loss of 0.33 units of body condition score.

	Weeks before lambing		
Liveweight (kg)	6 - 5	4 - 3	2 - 0
60	0.80	0.95	1.21
70	0.90	1.09	1.37
80	0.98	1.17	1.45

(O'Mara, 2000)

Understanding energy values in feeds

Under the NE system when comparing feedstuffs for energy, 1kg of air dried barley is taken as the standard measure of energy. Thus, 1kg of barley as fed contains 1.00 UFL or 1.00 unit of energy. Feed with a UFL value greater than 1.00 contains more energy than 1kg of barley. A feed with a UFL value less than 1.00 contains less energy than 1kg of barley. The energy requirements (UFL/day) for a twin bearing ewe assuming a loss of 0.33 units of body condition score is outlined in Table 1.

Concentrate energy value

There is strong tendency among farmers to only consider crude protein % and price when buying a concentrate feed. One very important feature about a ration that is often overlooked is the energy level in the concentrate. The label on the bag will clearly show the crude protein, ash, fibre, oil, mineral and vitamin inclusion levels. There is no requirement for compounders to display energy values. To add to the confusion most commercial ewe rations typically contain 6 to 11 ingredients without listing actual inclusion levels.

Steps to comparing energy values

1) When comparing energy values in feeds it is important to compare like with like i.e. compare all feeds per kg as fed or else per kg of dry matter.
2) A good ration should have an energy density of 0.95UFL or greater per 1kg as fed.
3) Use the data in Table 2 as a guide to compare the energy levels of common feedstuffs. The lower down the ingredient are in this table the lower its energy content is.

Table 2. Guide to energy contents per kg as fed in feedstuffs commonly used in sheep rations

Energy Level	Ingredient	UFL
High energy	Maize	1.05
	Distillers grain, maize	1.03
	Soya bean meal, hi pro	1.02
	Citrus pulp	1.01
	Barley	1.00
	Un-molassed sugar beet pulp	1.01
	Wheat	0.99
Medium energy	Maize or corn gluten feed	0.92
	Soya hulls	0.91
	Oats	0.89
	Rapeseed meal	0.88
Low energy	Palm kernel meal (expeller)	0.86
	Cotton seed meal (extracted)	0.83
	Cane Molasses	0.76
	Pollard/wheat feed meal*	0.70
	Grass meal (imported)	0.60
	Sunflower meal 25% CP	0.59
	Good hay 85%DM, 60DMD,	0.59

Protein requirements in late pregnancy

The ewe's requirement for protein increases in the last 3-4 weeks of pregnancy as shown in Table 3.

Table 3. Crude protein (g/day) requirements of a twin bearing 80kg ewe

Weeks pre-lambing	6-5	4-3	2-1
Crude protein (g/day)	145	€	230

(Adapted from MLC, 1983)

Protein quality in a concentrate

It is often assumed when comparing rations with the same crude protein % that you are comparing like with like. However, the crude protein % alone is not a good indicator of protein quality. A high quality protein for sheep is one that will resist been broken down in the rumen but is readily absorbed in the small intestine. This is often referred to a Digestible Undegradable Protein (DUP). In terms of untreated protein sources soyabean meal is a very good source of high quality protein or DUP. Untreated rapeseed meal is a poorer source of high quality protein or DUP. As per Table 4 treatments such as browning considerably improved DUP levels of both soyabean meal and rapeseed meal (Houdijk et al 2014). However the availability, palatability and energy value of rapeseed meal must be considered. It should be noted that maize gluten meal is very different to maize gluten feed. Soya bean meal should form a large portion of the protein source of the concentrate.

Table 4 Crude protein (CP) and digestible undegradable protein (DUP) levels in untreated and treated protein sources.

Feedstuff	CP (% in DM)	DUP (% of CP)	Treatment	DUP after treatment (% of CP)
Soya bean meal	51	33	Browning, formaldehyde	62
Rapeseed meal	35	17	Browning	70
Maize gluten meal	62	55		

(Houdijk et al, 2014)

Calculating the correct level of supplementary protein required by a ewe in late pregnancy will depend on the forage portion of the diet and the concentrate feeding level. The aim should be to achieve a protein intake of 230grams of crude protein per day for twin bearing ewes in late pregnancy. Examples of how this figure will be arrived at are listed below.

Example 1

Twin bearing ewes on excellent grass silage (75%DMD and 13%CP) receiving 0.6kg concentrates per head per day.
Requirement=230g/day
Estimated silage intake 0.9kg DM per day @ 13%CP = (900g x 0.13) = 117g
Balance required from concentrate (230-117) = 113g
Concentrate feeding level 0.6kg/ day.
Protein % required in concentrate = (Balance of protein required from ration (g/day)) x 100/ (Total quantity of ration fed),
Crude Protein Required in Concentrate = (113x100)/600 = 18.83%.

Example 2

Twin bearing ewes on grass silage (65%DMD & 10%CP) receiving 0.8kg concentrates per head per day.
Estimated silage intake 0.7kg DM per day @ 10%CP = (700g x 0.10) = 70g
Balance required from concentrate (230-70)=160g
Concentrate feeding level 0.8kg
Protein % required in concentrate = (160x100)/800 = 20%.

The above examples clearly demonstrate that the level of protein in the required in the concentrate needs to vary depending on:

(1) Roughage quality and intake characteristics.

(2) Concentrate feeding level.

Feeding of concentrate

Ideally, concentrates should be offered on a 'little and often basis'. This will reduce the drop in rumen pH which has an adverse effect on roughage intake. There are a number of key guidelines that are useful when sheep are being supplemented with concentrate feed aimed at minimising the disruption to roughage intake, including:

- Increase the concentrate feeding levels gradually over time. Maximum increase of 0.2kg every 3 days.
- When feeding quantities greater than 0.5kg daily, split into two feeds at least eight hours apart.
- Make changes to feeding regime including concentrate composition gradually.

Feeding space

It is important to have sufficient trough space to allow all sheep to eat concentrate feed at the same time. Table 5 outlines the space requirements for ewes depending on body weight.

Table 5. Space requirement

Type of Ewe	Meal Feeding (mm)	Roughage (mm)
Large (90kg)	600	200
Medium (70kg)	500	200
Small (50kg)	400	175

(DAFM, 2004)

Silage feed value

The Dry Matter Digestibility (DMD) of roughage has a key influence on its intake characteristics and feed value. Thus digestibility will also have a major impact on changes in ewe body condition & meal requirements in late pregnancy. Keady, (2012) reviewed studies at Athenry where ewes on average were fed a total 20kgs of meal in late pregnancy. He concluded that increasing silage DMD by 5% would increase lamb birth weight by 250g and lamb weaning weight by 0.95kg. Therefore, timely analysis of winter forage is important so as establish the correct time of introduction and the level of concentrate supplementation required.

Silage chop length

Chop length has a major effect on a ewe's silage intake. Shorter chop lengths encourage ewes to have higher intakes. In late pregnancy ewes will eat about 25% less of the flail harvested silage than the precision-chopped silage (Apolant and Chestnutt, 1985). Feeding big baled silage reduces intake due to long fibre length. Consequently, concentrate feeding levels can be reduced where precision chopped silage is offered.

Other silage characteristics

Low dry matter silages increase both straw usage and the risk of lameness. Silage pH or type of fermentation can also affect intake. Forage has a natural level of ash, however concentrations of ash over 10% indicate soil contamination, which is often associated with poor fermentation and a high risk of listeriosis and therefore, should not be fed to sheep (DEFRA / ADAS).

Housing date and body condition

House ewes while they are in good body condition. To reduce the risk of pregnancy toxaemia (twin lamb disease) and hypocalcaemia (milk fever) avoid housing ewes within the last 4 weeks before lambing. Body condition score ewes at time of scanning as all ewes will penned at that time. Target body condition score for ewes at key time of the production cycle are presented for mature ewes in Table 6.

Table 6. Target body condition score for ewes at key time of the production cycle for mature ewes

Time	Body condition score
Weaning	2.5
Mating	3.5
Scanning	3.5
Six weeks pre lambing	3.0
Lambing	3.0

Meal requirements in late pregnancy

Recommended meal feeding levels as determined by silage digestibility are shown in Table 6. For the lambing season of 2013 and 2014 similar recommendations were followed at the Teagasc Athenry research demonstration farm which contains 360 ewes (Creighton, 2015). The ewe type here are either Belclare or Suffolk crosses. The silage offered in late pregnancy was 74 DMD in 2013 and 72 DMD in 2014. The silage type was big baled silage. Only a 19% crude protein ration was fed. The average body condition score at mating, scanning and at lambing were 3.5, 3.4 and 3.3, respectively. In the past 2 years this feeding programme has resulted in lamb birth weights being close (±0.2kg) to the target of 6kgs for singles, 5kgs for twins and 4kgs for triplets.

Table 7. Recommended meal levels (kg/day)- unshorn twin bearing lowland ewes in good condition– ad lib silage (20% DM)

Silage quality	Weeks pre-lambing					Total (kg)
	10-9	8-7	6-5	4-3	2-0	
Excellent (75% DMD)			0.1	0.4	0.6	15
Good (70% DMD)		0.1	0.3	0.5	0.7	20
Moderate (65% DMD)		0.1	0.4	0.6	0.8	25
Poor (60% DMD)	0.1	0.3	0.6	0.8	1.0	40

Recommendations along with Table 7:

- The commencement of concentrate feeding of single bearing ewe should be 2 weeks later and 0.2kgs less than for twin bearing ewes.
- The commencement of concentrate feeding of triplet bearing ewes should be 2 weeks earlier and 0.2kgs more than for twin bearing ewes.
- Condition score ewes at scanning and at week 6 before lambing.
- Ewes below target BCS should be given meals 2 weeks earlier than the time shown in Table 7.

Mineral and vitamin supplementation

This is a complicated area with considerable interaction between minerals. Mineral and vitamin formulations are best left to professional nutritionists. It is important that concentrate feeds are correctly balanced and in particular for major elements such as Calcium (Ca), Phosphorous (P), Sodium (Na) and Magnesium (Mg). Vitamins E has an important role in lamb survival and vigour. When propionic acid treated grain is being fed the level of Vitamin E in the diet should be increased (NADIS). In order to bind the mineral / vitamin mix within the concentrate it is important that molasses is used. Consequently, most concentrate mixes will contain levels of molasses of between 4% and 8%. Coarse rations or blends including minerals without proper mixing and including a binding agent can be particularly dangerous for livestock if the mineral / vitamin mixture settles out during transport or delivery.

Water

A plentiful supply of clean drinking water is essential for ewes in late pregnancy. Housed ewes on high dry matter diets can consume up to six litres of water daily (Hynes, 2013).

Conclusions

1) Test silage as DMD dictates the time and amount of concentrate ration required.
2) Test each cut as quality varies between cuts.
3) Pregnancy scan as litter size and lambing date will also dictate the time of feeding and amount of ration required.
4) A good ration should have a UFL value of 0.95UFL or more as fed.
5) Avoid rations containing low energy ingredients.
6) Avoid rations containing a high proportion of medium energy ingredients.
7) Protein quality is important so check the protein source in the concentrate.
8) Soya bean meal should form a large proportion of the protein in the concentrate.
9) To calculate the relative price of different feeds use the Teagasc calculator available to clients at www.teagasc.ie

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Worm control strategies with reduced reliance on anthelmintics

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Gastrointestinal nematode infections reduce lamb productivity through anorexia but also through diverting resources to repair damaged tissues. This penalty on growth performance is directly related to the level of larval challenge. Work done at Moredun Research Institute more than 30 years ago has shown that lambs gain progressively less with increasing larval challenge, and that regular drenching in the presence of high larval challenge only partly avoids these losses (Coop *et al.*, 1982). These results are as valid now as they were back then, and highlight the importance of reducing pasture infectivity as a main aim to reduce (the consequences of) parasitism on sheep production. It should be noted that reduced performance and thus delayed finishing is only part of the costs of parasitism; additional costs arise from the purchase of anthelmintics and the often underestimated labour costs for drenching and removing faecal soiling prior to lambs going for slaughter.

In order to reduce pasture infectivity, sheep producers are relying heavily on anthelmintic drugs to reduce ewe and lamb faecal egg counts (FEC), as the latter is the main source of pasture contamination with gastrointestinal nematode parasites. However, the development of anthelmintic resistance but also consumer concern about drug residues and popularity of organic production systems, are highlighting the requirement for alternative approaches to control pasture infectivity and reduce our reliance on anthelmintics. This paper describes briefly four such alternatives.

Ewe protein supplementation

Whilst the importance of controlling the periparturient rise in FEC has been acknowledged for many decades, it remains unclear why it occurs. Research has shown that it is not associated with lambing *per se*, time of the year or hormonal changes. The underlying breakdown of immunity to parasites may be a consequence of the often-limited protein supply around lambing, because the available protein would be prioritised to lamb growth (e.g. milk production) over maintenance of immunity (Coop and Kyriazakis, 1999). Indeed, many recent studies have demonstrated that level of periparturient FEC can be reduced through improved protein nutrition, typically a minimum of 20% above assumed protein requirements. The main findings of these studies, carried out over the last 15 to 20 years, are summarized below; please see the recent review of Houdijk et al. (2012) for more details and bibliography.

- Protein supplementation at times when protein supply is limiting productivity would be expected to reduce ewe FEC and increase lamb weight gain, which is indicative of increased milk production. This benefit seems independent of infection pressure.

- Twin-rearing ewes excrete more nematode eggs than single-rearing ewes. In addition, the presence of body protein reserves reduces FEC at times of limited protein supply from the diet. These findings suggest that multiple-rearing, under-nourished ewes in relatively poor condition contribute mostly to pasture infectivity.
- Gradually increasing protein supply from scarce to more than adequate to twin-rearing lactating ewes first increases milk production to a maximum before it reduces worm burdens. This is direct evidence for the overall idea that scarce protein supply is preferably directed towards milk production rather than to immunity to parasites.
- Improving the nutritional status of the ewes can reduce FEC and worm burdens within days. Thus, rapid effects of ewe supplementation on parasitism and thus her contribution to pasture infectivity can be expected.
- Protein undernutrition may penalize immunity to parasites to a greater degree in high productive ewes such as Mules compared to those less strongly selected for improved productivity, such as Blackface
- The efficacy of protein supplementation on ewe productivity and parasitism may differ between protein sources. Recent evidence seems to indicate that protein supplementation using by-pass protein sources, such as xylose-treated soya bean meal, are likely more effective to increase ewe productivity and reduce FEC than simply feeding more protein that is degradable in the rumen.

Benefits of reduced ewe FEC are noted in lambs, as increased maternal protein nutrition delays parasite infection in lambs following turn out on clean pasture and improves lamb performance. In a recent trial, when ewes and their twin lambs were turned out on pastures previously grazed by wormy sheep, we observed that lambs from protein supplemented ewes, which had smaller FEC than their non-supplemented counterparts, grew faster and needed fewer drenches during the experiment, although lambs FEC was not affected by maternal protein nutrition. These results are shown below (Figure 1).

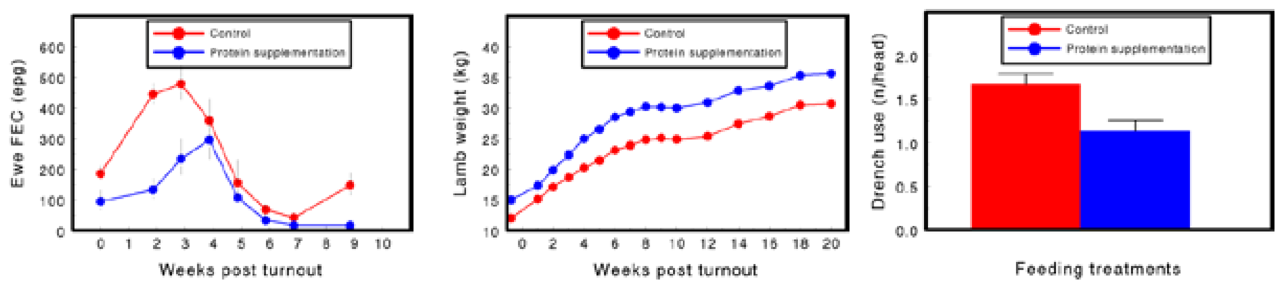

Figure 1. Impact of maternal protein supplementation on ewe FEC, lamb weight and lamb drench use; ewes and their twin lambs were turned out four weeks after lambing onto parasitologically contaminated pastures.

Chicory

Forage chicory (*Cichorium intybus*) is referred to as a "bio-active" plant because of its purported anti-parasitic properties. Chicory can be readily grown in the UK, is very palatable and although it has a lower dry matter level than typical grass-clover swards, protein, energy and mineral levels in the dry matter are greater (Table 1).

Table 1. Chemical composition of forage chicory compared to grass/clover.

	Forage chicory	Grass/clover
Dry matter (DM, g/kg)	111	220
Crude protein (g/kg DM)	229	89
Ash (g/kg DM)	106	55
Neutral detergent fibre (g/kg DM)	270	419
Acid detergent fibre (g/kg DM)	211	244
Oil (g/kg DM)	45	27
Metabolisable energy (MJ/kg DM)	12.6	12.0
Minerals		
Ca (g/kg DM)	8.9	4.7
Na (g/kg DM)	5.0	2.4
Mg (g/kg DM)	2.7	1.4
K (g/kg DM)	30.8	16.6
P (g/kg DM)	5.2	2.8
S (g/kg DM)	3.5	1.6
Zn (mg/kg DM)	80.6	20.5
Cu (mg/kg DM)	12.1	6.0
Fe (mg/kg DM)	220	64

A large number of studies have assessed chicory's anti-parasitic properties and thus its potential use for improved lamb growth and reduced reliance on wormers. The main findings of these studies are summarized below; again, please see Houdijk et al. (2012) for more details and bibliography.

- Short-term grazing on pure stands of chicory reduced lamb worm burdens by 40%, suggesting chicory plots may be used as deworming paddocks in rotational grazing.
- When ewes with twin lambs grazed newly established chicory (i.e. low infection pressure), we observed no effects on ewe FEC but 40% lower lamb FEC and 20% faster pre-weaning lamb growth than those grazing grass/clover.
- Post weaning, wormy lambs grazing newly established chicory had 65% lower worm egg counts and grew 25% faster than lambs grazing grass/clover, and pasture larval counts were still lower at the start of the following grazing season.
- Lambs reared on chicory had greater killing out percentages, better conformation scores and their loins were scored as having greater lamb flavour, compared to lambs reared on grass-clover.
- It is not completely clear how chicory's antiparasitic benefits can be explained but it has been suggested that they may arise from its anthelmintic compounds, its greater levels of protein and/or its broad-leaf structure, which impede vertical larval migration and thus reduced larval intake.

When ewes with twin lambs were turned out on previously grazed chicory instead of previously grazed grass/clover (i.e. contaminated pastures), ewe FEC was again not affected, but ewes were heavier and in better body condition at weaning. In that trial, grass-lover lambs needed more and earlier drenching, which biased effects on FEC, though prior to that influence, lamb FEC were lower and throughout the trial, lambs grew up to 50% faster (Figure 2).

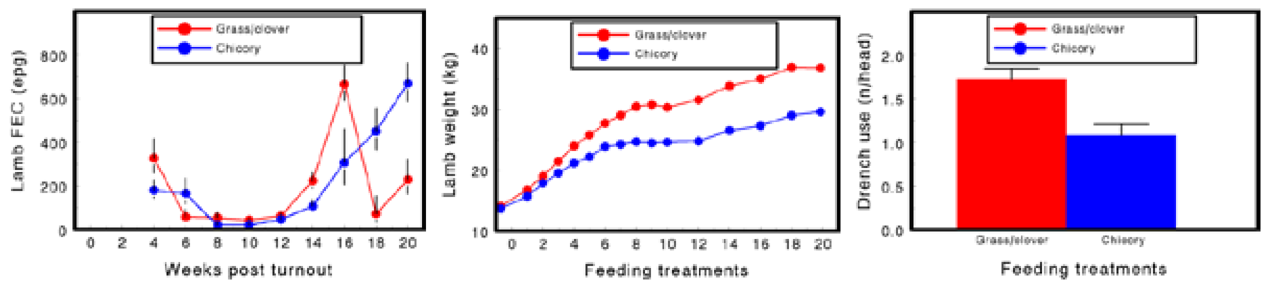

Figure 2. Impact of forage chicory grazing on ewe FEC, lamb weight and lamb drench use; ewes and their twin lambs were turned out four weeks after lambing onto parasitologically contaminated pastures.

Targeted selective treatments for lambs

It has been suggested that changing the use of anthelmintic treatments from suppressive to selective may assist to reduce the rate of anthelmintic resistance development. The question then becomes how to decide which sheep to drench. An increasing number of producers are aiming to base drench decisions on whole flock FEC testing, though the use of pooled samples from random sheep. Although this can dramatically reduce wormer input, it is not feasible to do this on an individual animal basis. Recently, a targeted selective treatment (TST) has been developed that makes use of deviations from expected weight gain to inform the drench decision. The TST is a so-called refugia-based approach to worming, where only a portion of animals is treated at any one time in order to maintain an anthelmintic-susceptible parasite population (Kenyon et al., 2013). The ability to effectively target worming relies on the identification of those animals that will most benefit from treatment, using short-term weight change. The individual identification of animals, to enable this method, is feasible through the use of Electronic Identification (EID).

In the research carried out at SRUC's Kirkton & Auchtertyre farms, where most of the land is hill rough grazing, with only 230 ha of improved and semi-improved pastures, 900 hill ewes have been allocated to two system groups, one managed conventionally (control - CON), and the other with a Precision Livestock Farming (PLF) management protocol (Morgan-Davies et al., in preparation). All animals are electronically identified using an EID tag. In the PLF group, the lambs have been subject to the TST approach. They have been weighed monthly after marking (June) and wormed only if they did not reach their individual target weight. Lambs in the CON group have been wormed using a whole flock approach, based on pooled faecal samples, by litter size groups. If the faecal egg count was >500 eggs/g, all lambs in that group were wormed; if it was lower, the lambs were not wormed.

After two years of research (2013 and 2014), it was observed that by using a TST approach, the amount of anthelminthic products used on the farm was reduced by 53% on average, without compromising the lambs final weights (Figure 3). Additionally, provided the farmer has access to an automated EID reader on a weigh crate, the TST approach so far has greatly reduced time and costs spent worming the animals. Over the 2 years, the total savings (labour and wormer) averaged £69 for 100 lambs.

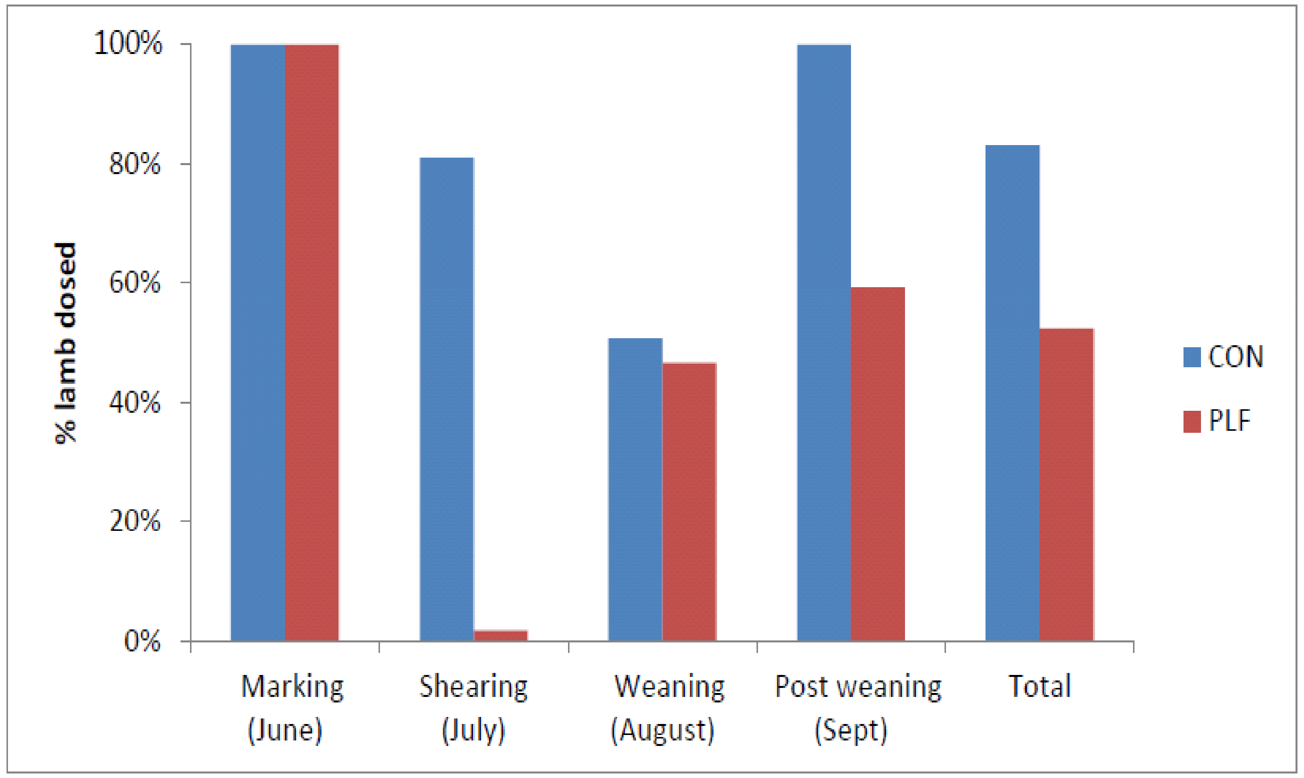

Figure 3. Percentage of lambs dosed, based on whole flock FEC (CON) or TST approach during precision livestock farming (PLF).

A third year of observations is to be added, not only to further test the approach, but also to account for variation between years, as different years can have differing levels of parasite challenge. However, so far, this research is not only demonstrating that anthelmintic use can be reduced with maintenance of sheep productivity, but also a good example of the use of EID technology for the management of hill sheep flocks.

Breeding

Breeding may offer a long-term solution to reduce (the consequences of) gastro-intestinal parasitism in sheep production systems. Breeding for resilience essentially means breeding for improved productivity whilst animals are under challenge. Such a strategy can be expected to improve productivity over time but has the danger of building up pasture infectivity, so that benefits may actually reduce over time. Breeding for resistance is often referred to as selecting for low FEC. Between-breed and within-breed variation in FEC can be considered (Stear *et al.*, 2007). In general, improved breeds have higher FEC than native breeds (Houdijk, 2008). However, breed comparisons are often confounded by differences in productivity, as breed improvement usually means increasing productivity. When comparison between breeds takes place at similar levels of nutrition, then the higher productive ones would be under higher degree of nutrient scarcity, which could be a reason for a higher FEC (Coop and Kyriazakis, 1999). Thus, care should be taken to compare FEC between breeds.

The possibilities of breeding for reduced FEC through exploiting within-breed variation have been demonstrated in New Zealand and Australia (see Stear *et al.*, 2007 for references), and it is well recognized that the FEC is heritable, with an h^2 of ~0.3. In the Southern hemisphere, estimated breeding values for log-transformed FEC in selection lines have been more than 25% lower than those in control lines, translating in a 25-fold reduction in FEC. However, selection for reduced FEC may be negatively correlated with production traits. Also, it has been observed that long-term selection for low FEC may increase incidence of diarrhoea. Thus, it would be useful to include selection for reduced FEC in existing breeding goals, alongside selection indices for production traits, although this would mean that rate of progress may reduce.

SRUC is undertaking a large study in which breeding goals for Scottish Blackface sheep are expanded to also breed for reduced FEC. They are being compared to sheep subjected under commercial breeding goals in order to investigate benefits on sheep productivity, health and welfare. The aims of this study are therefore to estimate genetic properties of sheep productivity and FEC, but also test if two additional indicators of internal parasitism could be used in sheep breeding programmes that may in turn, lead to more farmers engaging in breeding for host resistance to parasites: (i) faecal soiling ('DAGG') scoring and (ii) the CARLA test, that measures antibodies (IgA) against worm larvae in sheep saliva. Animals with high levels of such antibodies are better at preventing worms establishing in the gut, although the test has not yet been validated in the UK (Conington *et al.*, 2014). It is hoped that a demonstration of benefits of selecting for improved resistance to parasites will assist implementing breeding for reduced FEC, which has not been taken up (yet) in the UK.

Conclusions

This short overview shows that nutritional, drench management and genetic approaches have the potential to reduce (the consequences of) gastrointestinal nematode parasitism in sheep and to reduce reliance on anthelmintics Opportunities exist to exploit maternal protein supplementation, grazing on chicory, performance-based drenching and selecting for reduced FEC to achieve reduced pasture infectivity (through reduced worm burdens and FEC), increased lamb production and reduced wormer usage. However, it is unlikely such approaches will be used in isolation. Rather, they could find their place in a holistic approach that aims to reduce our reliance on anthelmintics for the control of gastrointestinal nematode parasites. As such, these approaches would be of relevance for both conventional and organic farmers.

Acknowledgements

Scotland's Rural College (SRUC) receives funding from Scottish Government (Rural and Environment Science and Analytical Services, RESAS). For further information on protein nutrition and chicory, please contact Jos Houdijk (jos.houdijk@sruc.ac.uk), on TST, please contact Claire Morgan-Davies (claire.morgan-davies@sruc.ac.uk), and for breeding to reduce parasitism, please contact Joanne Conington (joanne.conington@sruc.ac.uk).

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Improving lamb survival and reducing lambing difficulties – a win-win opportunity

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Improving lambing ease and lamb survival improves flock efficiency, and ticks the box for sustainable production, reduced waste and lower carbon emissions. The number of live lambs sold from the farm per ewe is the single biggest influence on farm income from sheep, and so maximising the chances of survival makes very good business sense. Ensuring that live lambs born survive until they are sold or kept for breeding requires investment in knowledge to ensure effective disease prevention, shelter provision, and nutritional requirements for pregnancy and lactation to maximise colostrum production and lamb growth rate. Identifying which sheep cohorts are at the greatest risk of having high levels of mortality and most likely to have difficulties at lambing helps to target additional management interventions for these groups.

Not only is the survival of lambs in extensive sheep production systems a major contributing factor to the economic efficiency of these farms, it is also an indicator of good animal welfare. Estimates of lamb pre-weaning mortality vary considerably between 10 and 30% and most of these mortalities occur within the first 3 days of postnatal life (Dwyer, 2008). Two main approaches can be used to improve these key indicators of flock productivity. Firstly, specific management practises can be put in place to maximise conception, reduce lamb losses particularly at around lambing time, ensure good supply of colostrum and easier lambings. Secondly, a closer look at breeding practise, careful monitoring of ewe performance and use of estimated breeding values (EBVs) to select sires with good lambing ease and growth characteristics will avoid falling into the trap of relying only on eye to judge likely future performance.

Lamb mortality

Lamb survival depends fundamentally on the establishment of a bond between ewe and lamb, such that the lamb can obtain colostrum and milk from the dam, and the behaviour of both ewe and lamb contribute to lamb survival. The following are key stages for lamb losses and understanding what influences each, may help to minimise lamb mortality:

- Failure to conceive
- Embryo mortality
- Foetal mortality/abortion
- Stillbirths
- Pre-weaning mortality
- Maternal mortality

It is reported that around a third of all lamb losses are due to embryo mortality, 30-37% from foetal mortality, abortion and stillbirths, and about 37% are pre-weaning mortality, with around a quarter being neonatal. Lambs lost due to ewe mortality is around 1-2%.The main causes of lamb mortality are related to trauma experienced during the birth process, failure of neonatal adaptation to postnatal life (e.g., inability to maintain body temperature, low lamb vigour, poor establishment of a maternal bond), infectious disease, functional disorders, and predation. The relative prevalence of any of these causes of mortality varies by location and farm management system. However, the single greatest predictor of lamb mortality is birth weight. Heavy lambs may experience difficult deliveries and die during birth whereas low birth weight lambs are more likely to experience starvation and hypothermia. A New Zealand study (Muir and Thomson, 2009) collected fate data from 5,447 lambs born to ewes between 2005 and 2008. A large number of factors appear to influence lamb survival including weather, ewe genotype, litter size, lamb birth weight, ewe behaviour, ewe age, ewe nutrition, ewe health, ewe colostrum and milk production, mineral status, stress and uterine environment. The biggest contributor to lamb mortality is maternal stress prior to lambing. Ewes that had higher beta-hydroxy butyrate (BOH) levels prior to lambing had more dead lambs at birth suggesting a poorer uterine environment. Lambs that died of starvation also appeared to be born to ewes with higher BOH levels. Lambs that died around or soon after birth tended to be smaller and were probably less vigorous, had limited nutrition in utero, were more vulnerable to adverse weather and less competitive for the ewe's milk. Survival rates were 88%, 86%, 70% and 43% for singles, twins, triplets and quads, respectively. Of the 694 lambs autopsied, 14% died prior to the birth process, 16% died of hypoxia, 26% of starvation and 20% of infection.

Lamb birth weight and lamb survival

The distribution of lamb birth weights for 21,738 Scottish Blackface lambs at SRUC farms (Kirkton /Auchtertyre and Castlelaw) are shown in Figure 1 below. The majority (95%) of birth weights are between 2.3kg and 5.3kg.

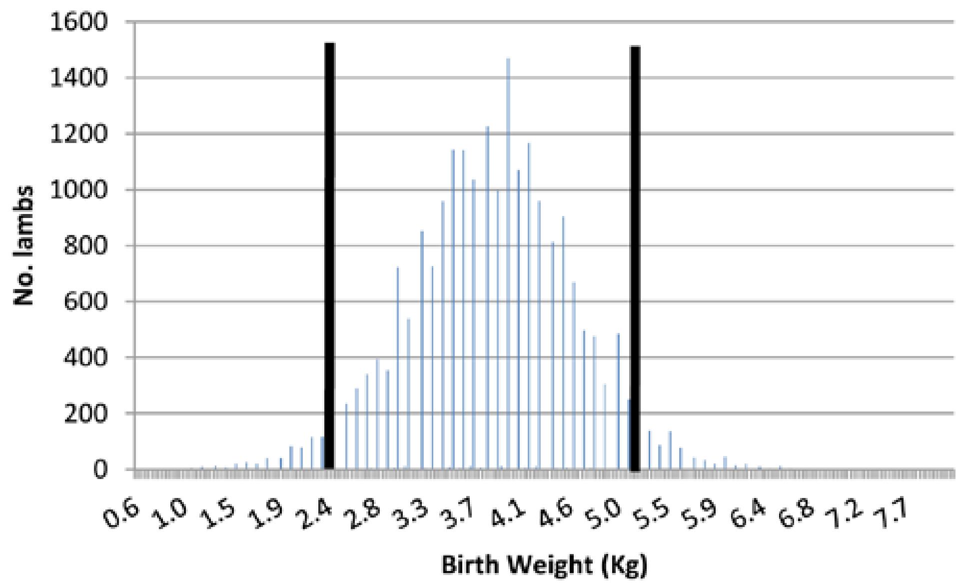

Figure 1: Distribution of lamb birth weights on SRUC experimental hill farms

The relationship between lamb mortality and lamb birth weight in the same Scottish Blackface (SBF) experimental lamb population was reported in 2007 by Sawalha et al (Figure 2a) and also estimated for National (Signet) data reported by Conington et al., 2012 (Figure 2b). It is clear that very low and very high birth weight lambs have the highest risk of mortality and therefore any steps to avoid such birth weights will improve lamb survival.

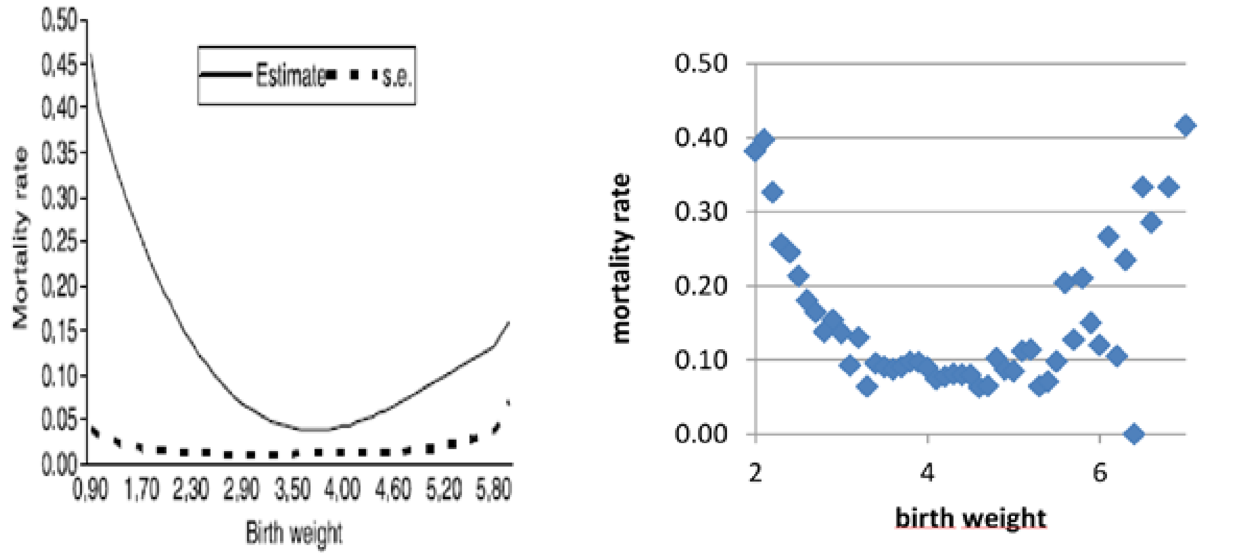

Fig 2a: Experimental data (n=15,652) **Fig 2b:** National data (n=173,895)

Figure 2: Mortality and lamb birth weight in experimental (2a) and National (2b) Scottish Blackface lambs. Both studies show that an intermediate optimum birth weight exists below and above which lambs are at an elevated risk of mortality.

Lambing difficulty and lamb survival

Ewe breeds that are generally reared under intensive conditions at lambing, with a high degree of human intervention and assistance in the lambing process, experience more difficult deliveries than breeds that have been managed under more extensive management, when managed under similar conditions (Dwyer et al., 1996; Dwyer and Lawrence, 2005). It is probable that assistance with delivery may have reduced the natural selection pressure on ease of birth in the ewe, which several breeders are now attempting to overcome by recording and culling animals that required assistance at birth and not selecting their offspring as replacement ewes (Conington et al., 2010). In a study of over 8,000 lambings spanning 6 years, the prevalence of dystocia was reported for Scottish Blackface sheep as being 7% (Ilska et al., 2010) which is lower than reports for other breeds (MacFarlane et al., 2010). The survival of the neonatal lamb is dependent on the expression of appropriate behaviours between both the ewe and the lamb leading to the formation of a strong relationship between them. Any disruption to the progression of maternal bonding such as a difficult lambing leads to higher risk of lamb mortality. The recognition of her own lamb from olfactory cues occurs in a sensitive period which may only be present for the first 30 to 60 min after birth. If anything prevents the ewe from interacting with her lamb during this time window, she may fail to establish selectivity with her own lamb. Lack of development of maternal recognition will then result in rejection of her own offspring, which is more common in first time mothers.

Difficult births are a key influence on the disruption of neuroendocrinological processes that are important for the onset of appropriate maternal and lamb behaviours occurring immediately after birth such as olfactory cues involved with udder seeking behaviour and vocalisation between dam and offspring (Dwyer, 2014). Ewes which experience a prolonged or difficult delivery are slower to begin grooming their lambs, and show reduced grooming behaviour and are more likely to reject their lambs than ewes delivering after short or uncomplicated births. Prolonged or difficult births are associated with pain and stress in the mother and may lead to an increase in maternal circulating hormones (e.g. cortisol) which (at least in cattle), leads to lower expression of maternal grooming behaviour. If ewes are exhausted from a prolonged delivery, and are slow to stand and interact with their lambs, failure to form a selective bond with their lamb may result in their rejection of the lamb.

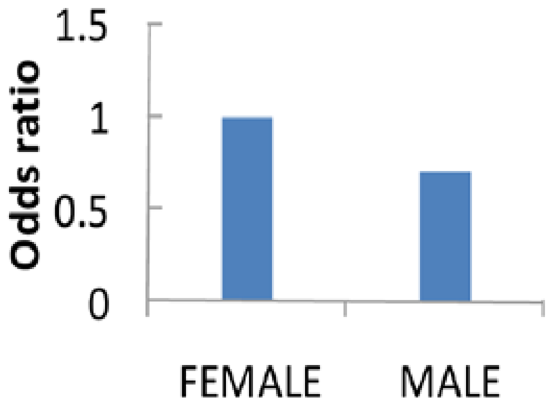

Figure 3. Male vs female lamb survival

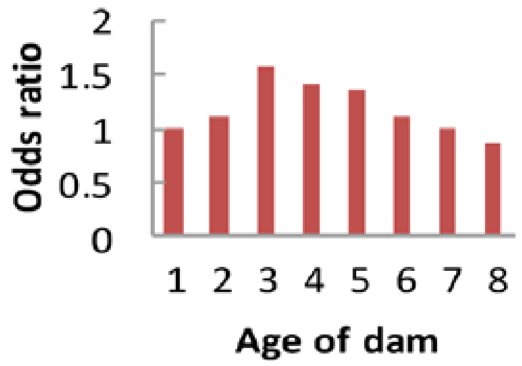

Figure 4. Lamb survival according to dam age

Breeding for increased lamb survival

Improving lamb survival through breeding is very relevant for extensively-managed flocks such as hill breeds, or for flocks where minimal intervention by man is practised. This is because it identifies individuals and families of sheep that differ in their inherent ability to lamb unaided, nurture and rear their young, as a well as identifying offspring that are less viable at birth and those that have either very low or very high birth weights. A recent UK study using data from Signet's Sheepbreeder performance recorded Scottish Blackface flocks comprised 173,895 lamb records from 1976-2011 to determine the genetic basis to lamb survival (Conington et al., 2013). Significant influences on lamb survival included flock, year, age of dam, sex of lamb, birth type and birth weight. Compared to male lambs, female lambs have a 1.3 times better survival odds (Figure 3) and lambs from 3 year old ewes are 1.4 times more likely to survive compared to lambs from 2 year old ewes and have the highest survival odds compared to all other ewe ages (Figure 4). The study showed that the genetic basis to lamb survival was low, but within published estimates for this trait. New research is currently underway to determine if the results for other breeds are similar and to integrate lamb survival into UK national sheep genetic evaluations.

The impact of selection for productivity on the incidence of difficult lambings was investigated by Lambe et al., (2006), when comparing three genetic lines on two farms. They showed that that there has been no significant change in the incidence of ewes requiring assistance at lambing as a result of selecting Scottish Blackface ewes for improved carcass and maternal performance compared to a control line, or to a line selected by normal commercial (visual, or 'by eye') methods. However, there was a significantly higher incidence in the latter line compared to the control line, which was maybe due to visual selection for a particular body shape which also increased lambing difficulties. Breeding directly for aspects affecting lamb survival such as ease of lambing is already ongoing by the Texel Sheep Society in the UK, using a 5-point lambing ease scale (MacFarlane et al., 2010). Continuing to broaden breeding goals to include aspects of lamb survival, disease resistance and lambing ease will have a positive welfare and economic benefit to improve flock efficiency, sustainability and reduce greenhouse gas emissions.

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Biosecurity for the Sheep Flock in Ireland

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Ireland has seen the relatively recent importation of many diseases such as sheep pulmonary adenocarcinoma (Jaagsiekte) and caseous lymphadenitis (CLA). Furthermore, memories of the Foot and Mouth Disease outbreak of 2001 underline the importance of biosecurity at both national and individual flock level. The industry needs to raise awareness of biosecurity amongst sheep farmers, as it is critical when purchasing replacement or foundation stock, including rams, that farmers are cognisant of the health status of the incoming sheep. Some of the most important diseases, which can be 'bought in' include sheep scab, resistant internal parasites, contagious ovine digital dermatitis and orf. Biosecurity practices often offer a bewildering array of 'to-do' lists for farmers which may be contributing to less than optimal implementation in both commercial and pedigree flocks. This short paper and its accompanying presentation is not intended to be a comprehensive review of biosecurity but a reflection on some practical measures that may be taken at farm level to reduce risk. Hopefully, it will serve to increase the awareness of 'buying in disease' on Irish sheep farms.

What is biosecurity?

Biosecurity is a strategy to prevent the introduction of infectious disease onto a sheep farm and to control its spread within the farm should disease occur. Biosecurity has two components; **bioexclusion and biocontainment**. Bioexclusion refers to measures designed to avoid the introduction of infection. Biocontainment relates to measures to limit within-farm transmission of infectious disease and the onward spread to other farms. Biosecurity is about risk reduction; no biosecurity plan will be 100 % effective. Biosecurity also relates to those diseases of sheep, which are transmissible to humans such as orf and toxoplasmosis. In conclusion, ***keep disease out and contain it if and when it gets in.***

Do you know the disease status of your own farm?

Before we consider those infectious diseases we want to keep out of our sheep farms in Ireland, we should first reflect on the disease status of our own flocks. Therefore, the first question to ask is do we know the infection status of our flocks as it applies to the list of the diseases shown in Table 1? This is a fundamental flock health management issue. If we do not know the infectious disease status of our flocks, then we need to begin the process of establishing this status; this is particularly significant for pedigree flocks but it also applies to commercial flocks.

Which diseases are we talking about?

Table 1 contains some of the most important infectious diseases present in Ireland. This is not an exhaustive list and it includes a number of diseases that are notifiable under the Diseases of Animals Act (1966).

Table 1. Some infectious diseases of Irish sheep subject to biosecurity (*Notifiable to the Department of Agriculture)

Disease	Cause	Vaccine Available in Ireland
Sheep Scab*	Mite (*Psorptes ovis*)	No
Footrot	Bacteria (*D. nodusus/ F. necrophorum*)	Yes
Contagious Ovine Digital Dermatitis (CODD)	Bacteria (*Treponeme* spp)	No
Orf	Parapox virus	Yes (**Never** use the vaccine in a closed, orf-free flock)
Sheep Pulmonary Adenocarcinoma* (Jaagsiekte)	Jaagsiekte Sheep Retro Virus	No
Caseous Lymphadenitis*	Bacterium (*Corynebacterium pseudotuberculosis*)	No
Johnes Disease*	Bacterium (*M.a paratuberculosis*)	No
Enzootic Abortion*	Bacterium (*Chlamydophilia abortus*)	Yes
Toxoplasmosis	Parasite (T. gondii)	Yes

Sheep diseases which are not present in Ireland but which present a 'real and present danger' include Maedi Visna, Peste des Petits Ruminants and Contagious Agalactia.

Are you aware of your own flock biosecurity?

The intensive pig and poultry industries have the most advanced and stringent systems of biosecurity internationally and the sheep, dairy and beef sectors are lagging behind. In terms of your own awareness of biosecurity, ask yourself the following questions:

1. Do you have a closed flock?
2. Do you quarantine purchased/newly-introduced animals for 4 weeks?
3. Do you check the disease status of the flock of origin?
4. Are your grazing boundaries stock-proof?
5. Do you provide and maintain cleaning/disinfection facilities for visitors?
6. Do you import slurry?
7. Do you 'borrow' colostrum for feeding?
8. Do you share animal equipment with neighbours?
9. Do you wash and disinfect animal equipment after use?

Biosecurity into practice - challenges

The approach to biosecurity should be based on risk and it should be practical. We must raise the awareness of 'keeping disease out'. We should explore practical, relatively inexpensive ways of reducing the risk of bringing infectious disease onto the farm. However, there are many challenges to this strategic approach and these include the economics of veterinary diagnostic testing, the variable sensitivity and specificity of certain tests, the challenge of keeping a 'closed flock' and fragmented farm boundaries and fencing. However, all the diseases listed in Table 1 are causes of important economic loss to the sheep farmer and of welfare concern so ignoring the issue will not make it go away. International literature suggests poor implementation of biosecurity is associated with confusing overly complex messages and the classical sociological dilemma known as the 'intention-behaviour deficit'

Some key flock health questions relevant to biosecurity

1. Have you created a flock health plan with your veterinary practitioner and other agricultural advisors?
2. What confidence do you have about the infectious disease status of your flock?
3. Do you know if you have any particular infectious disease (e.g. orf) on your farm?
4. How much of this infectious disease (prevalence) do you have on my farm?
5. If the flock is free of a particular disease then do you have a biosecurity plan to keep it out?
6. If the infectious disease is present in my flock, do I have a health plan to contain and control the disease with the aspiration to eradicate the disease at farm level?

Quarantine: *Purchased sheep represent the greatest biosecurity risk and should be quarantined and observed for 4 weeks*

We purchase animals that *appear* healthy and we hold them for a period:

1. In case they are pre/sub-clinical and are incubating / carrying a disease
2. So they can be closely observed in case the disease wasn't detected clinically before purchase
3. To allow them to be tested for infectious disease as appropriate
4. To allow them to be vaccinated for infectious disease as appropriate
5. To allow them to be treated for a disease as appropriate

Quarantine refers to the isolation of sheep in an area that prevents direct contact with other livestock and the recommended period of quarantine ranges from 3 to 6 weeks but commonly 4 weeks is advised to cover the period of greatest risk of clinical disease after purchase. Quarantine areas (buildings and pens) should ideally not share the same airspace as resident animals. The farther away new animals are kept away from resident animals, the better the quarantine will be. During the quarantine period, the sheep should be observed closely. A veterinarian should promptly examine any animals showing any sign of illness.

Neither farmers nor marts will knowingly sell infected animals and legislation in this area is contained within the Animal Health and Welfare Act (2013). Sheep farmers should liaise with their veterinary practitioners for advice and guidance, as animals undergoing quarantine should be subjected to veterinary examination. Warning signs include loss of body condition, increased breathing rate, swelling of the lymph glands, scratching, lameness or discharge from the eyes. Strategies to reduce the risks associated with reintroduced sheep are in principle similar to those for purchased animals

Risks to human health

Several of the biosecure diseases (orf, toxoplasmosis, enzootic abortion) are transmissible to humans so be aware of your own health and safety and always wear disposable gloves when working with sheep.

Feed biosecurity

Prevent access of birds, rodents and pets including cats to stored feed. Ensure farm dogs are treated for tapeworm.

Testing sheep before movement

Laboratory testing prior to animal introduction is recommended for many infectious diseases and will mitigate the risk of introduction of infection. In general, the consequences of a false negative far outweigh those of a false positive; sensitivity should be favoured over specificity for pre-introduction tests. The premium sheep health schemes operating in Scotland are excellent examples of the application of serological testing to reduce the risk of introducing infectious diseases such as Enzootic Abortion of Ewes (EAE) and Caseous Lymphadenitis (CLA). Maedi Visna, a viral disease not present in Ireland is also subject to control. The ELISA for CLA detects antibodies to *Corynebacterium pseudotuberculosis*, the bacterium that causes the condition. It can identify infected animals before they develop the characteristic external abscesses in the lymph glands, and is also effective in detecting sheep with only the internal form of the disease. Such animals would otherwise carry the infection without detection and represent the greatest threat in spreading the disease from one flock to another.

Quarantine treatments

In some cases, targeted medication can eliminate carrier status or reduce the probability of a carrier becoming infective. Examples of these include treatments under veterinary supervision to remove resistant worms and sheep scab and footbathing against conventional footrot, which would also serve to 'flush out' any sheep carrying or incubating contagious ovine digital dermatitis. All feet should be trimmed, inspected for footrot and foot bathed weekly in a 10% zinc sulphate solution. New purchases should not be allowed to join the resident sheep until they have been treated to remove anthelmintic resistant stomach worms. Equipment should not be shared between isolated animal areas and resident animal areas.

Before adding animals to your flock remember these principles:

- The health status of the source flock/s should be evaluated. Ask specific questions about the diseases that concern you. Find out specifics about management practices that might affect the flock's health.
- Replacements should ideally be bought from closed flocks of known disease status. A "closed" flock is defined as one where new animals have not been brought in for three or more years
- Number of source flocks should be minimized.

Biosecurity is a component of good flock health planning

- Plan a routine flock health program with your veterinarian that includes vaccination and other disease prevention measures; it is less costly and more economical than cleaning up problems. Biosecurity is essential in maintaining good flock health.

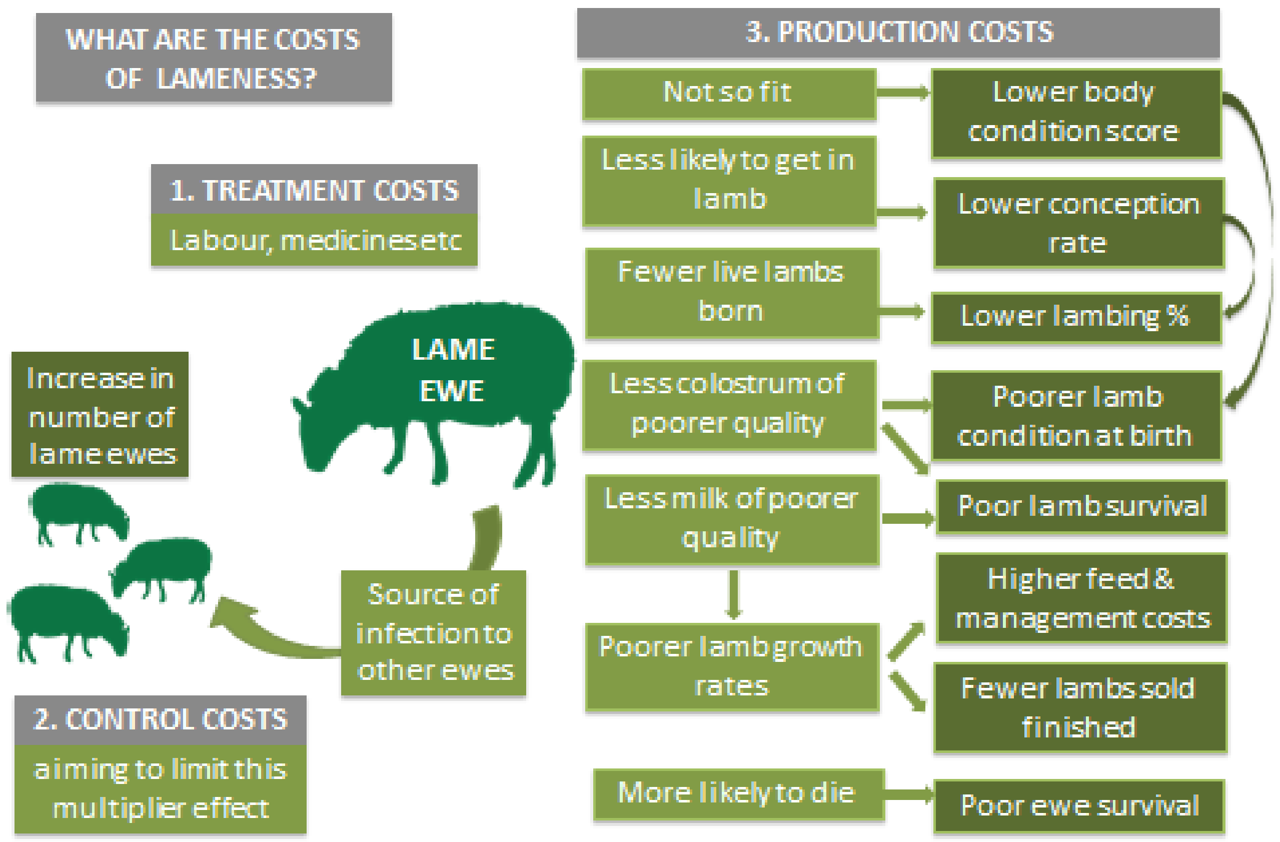

Figure 1: The costs of lameness

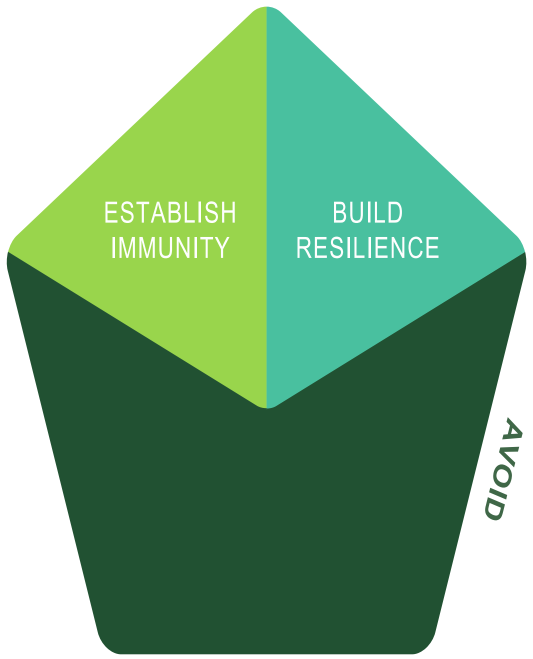

Figure 2: The Five Point Plan to control foot rot

Lameness in sheep

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High levels of sheep lameness remain one of the great challenges faced by our industry despite proven and effective control measures. This presentation discusses the diagnosis of common causes of lameness in sheep, the economic costs of ewe lameness and possible control measures that can be undertaken on farm.

Table 1: The common causes of lameness in sheep

Diagnosis	Description	Effective treatments
SCALD/STRIP	Moist, painful inflammation of skin between the digits. No lifting of hoof (Note that in adult sheep, scald is usually early foot rot and probably should be treated as such)	Antibiotic sprays or footbaths sufficient in lambs
OOTROT	Starts between digits but progresses to under-run hoof Distinctive smell Infected sheep will spread infection Chronic cases have misshapen hooves	Injectable antibiotics Vaccination
CODD (contagious ovine digital dermatitis)	Very painful & invasive Lesions start at top of hoof Rapid spread to under-run hoof wall	Injectable antibiotic and antibiotic spray together Antibiotic footbaths
SHELLY HOOF	Accumulation of debris at lower edge of foot which separates sole and wall along the white line Often not associated with lameness	Treatment only necessary if lame Careful paring may be useful
WHITE LINE ABSCESS	Following shelly hoof, infection tracks up white line and bursts out at the top of hoof.	Injectable antibiotics
TOE GRANULOMA	Fleshy 'strawberry' lesion that grows at toe following over-trimming. Difficult to treat but easy to prevent – don't trim!	Injectable antibiotics if infected and pack with copper sulphate

Control measures can be summarised within the Five Point Plan (figure 2) which has been used successfully in the control of foot rot on a number of farms in the UK (Clements and Stoye, 2014).Lame sheep are costly to any farm business due to the costs of treatment, control and most significantly due to lower productivity (figure 1). The cost benefit of different control measures can be compared using a computer model (table 2) developed by the University of Reading (http://www.fhpmodels.reading.ac.uk) which is available to download, free of charge, along with the software required to run it.

1. **Treat** - It is essential that all lame sheep are caught and treated effectively which will include use of an injectable antibiotic for all cases of foot or CODD.
2. **Avoid spread** – Both foot rot and CODD are infectious disease which will spread between sheep at areas of high sheep traffic and as they are gathered. Footbaths can be helpful to reduce the spread of disease when sheep are already gathered and to treat scald in lambs.
3. **Vaccinate** – Use of the vaccination has been shown to reduce levels of foot rot significantly by protecting individual sheep and lowering the level of challenge on the farm. Computer modelling shows that there is a cost-benefit to vaccination when levels of foot rot exceed 2% of the flock at any one time.
4. **Cull** – It is recommended that persistent offenders (sheep that are recurrently lame) should be culled. This means that records must be kept so that the same ewes are not retreated on multiple occasions. These ewes are not paying their way and are a constant source of infection to others.
5. **Quarantine** - All incoming sheep should be quarantined to avoid the introduction of a more virulent strain of foot rot or CODD.

Table 2: Costs of foot rot on a farm of 100 ewes. Figures calculated using the Reading University Footrot Model (found at http://www.fhpmodels.reading.ac.uk) (Assumptions: cull ewe=£60; fat lamb=£70; store lamb=£40; collection of fallen sheep=£12; formalin costs £1 per litre; vaccine costs=£0.80 per dose; Antibiotic costs=£1.30 per ewe. Assumes it takes one hour to footbath 100 sheep, four hours to vaccinate 100 sheep & half an hour to catch a lame ewe)

Control Strategy	Cost per ewe in the flock due to treatment/ control measures	Cost per ewe in the flock due to production losses	Total cost per ewe in the flock
10% lameness due to foot rot. No treatment or control undertaken	0	£14.53	£14.53
10% lameness due to foot rot. Farmer footbaths in formalin once a fortnight throughout year	£2.89	£11.87	£14.80
10% lameness due to foot rot. Farmer vaccinates against foot rot twice a year	£2.20	£6.50	£8.70
10% lameness due to foot rot. Farmer promptly catches and treats lame ewes with antibiotic and vaccinates twice a year	£2.70	£2.60	£5.30
3% lameness due to foot rot. Farmer promptly catches and treats lame ewes with antibiotic and vaccinates twice a year	£2.50	£1.10	£3.60

Trimming

Foot trimming was long recognised as an appropriate management technique for sheep until considerable research suggested that routine trimming can increase levels of lameness (eg. Wassink et al., 2003). More recently it was shown that even trimming the hooves of lame sheep may lengthen the time it takes for them to heal (Kaler et al., 2010). Recent studies of lame adult ewes on commercial farms in Gloucestershire, Northumberland and Yorkshire have been funded by the retailer J Sainsbury's and the English levy board, EBLEX. These studies compared the effects of trimming some randomly selected lame ewes compared to not trimming others and have provided answers to farmers who questioned what sheep feet would look like in the months following lameness. Results from these studies suggest it is often not necessary to trim misshapen claws though lame sheep should be treated quickly and effectively with an injectable antibiotic to clear up any infection. Sheep feet become overgrown and out of shape when they are infected with either foot rot or CODD. They may be more likely to become infected if they are damaged but not necessarily if they are overgrown. It is very important to promptly treat any infection but not necessarily to trim the foot (figures 3-7).

Trimming sheep feet does not necessarily keep them tidy as healthy sheep hooves can grow a couple of inches in a year – and perhaps even more when there has been some insult such as an infection or after they have been trimmed. Even careful trimming does not mean that the foot will still be a neat shape after six weeks and it may cause irregular growth (figures 8 & 9). It is not recommended to carry out routine foot trimming of sound ewes. On some farms it has been shown that trimming infected feet delays their recovery. Careful trimming should only be considered in cases of shelly hoof, if the hoof shape is encouraging debris to accumulate or if the hoof is so overgrown that its shape is itself causing lameness. In this case, cautious trimming, well clear of any sensitive tissue, will probably not cause further harm though it could be considered as a 'cosmetic' trim, not necessarily beneficial.

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Figures 3-7: On 16th May 2014 (figure 3), both feet were infected with foot rot and the ewe was severely lame. She was treated with injectable antibiotic but not trimmed. On 6th June (figure 4) she was walking much better; she was not trimmed and no further treatment was given. On 4th July (figure 5), 1st August (figure 6) and 15th September (figure 7) she was completely sound and her hooves developed back to a good shape despite no trimming at any stage. This ewe was at grass all summer and had not walked on hard surfaces.

Figure 8 & 9 indicate how quickly hooves will become overgrown. Only six weeks before these photos were taken, each of these feet had been carefully trimmed.

Conclusion

Lame sheep represent a significant welfare and financial cost to the sheep industry despite proven and effective control measures. Some shepherds tolerate too many lame sheep, so on these farms there is a high weight of challenge facing both ewes and lambs and causing yet more lameness and significant costs. However on other farms, there are shepherds who have embraced the control measures so that they consistently have low numbers of lame ewes which means that every one that is lame can be treated within a timely manner.

Acknowledgements

The author would like to thank J Sainsbury's, EBLEX, RDPE Skills Framework, Jake Freestone, Phillipa Page, Rheinallt Jones, Steve Dunkley, Tim Kelsey, Emily Reeves and Iain Robertson for funding, practical help and the use of photos.

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