MONITOR FARM Scotland

A CASE STUDY INVESTIGATING LAMB MORTALITY ON A SCOTTISH COMMERCIAL SHEEP FARM: A FOCUS ON COLOSTRUM QUALITY AND FAILURE OF TRANSFER OF PASSIVE IMMUNITY

PROJECT IN COLLABORATION WITH:

THE STEWARTRY VETERINARY CENTRE
Castle Douglas & Dalbeattie
Tel: 01556 502263

University of Glasgow
School of Biodiversity, One Health & Veterinary Medicine

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AUTHORS AND AFFILIATIONS

Alexandra S. Haggerty, The Stewartry Veterinary Centre, Oakwell Road, Castle Douglas, DG7 1JT, Scotland, United Kingdom.

Katharine S. Denholm, School of Biodiversity, One Health and Veterinary Medicine, University of Glasgow, 464 Bearsden Road, Bearsden, Glasgow, G61 1QH, Scotland, United Kingdom.

Kim Hamer, School of Biodiversity, One Health and Veterinary Medicine, University of Glasgow, 464 Bearsden Road, Bearsden, Glasgow, G61 1QH, Scotland, United Kingdom.

SUMMARY

Neonatal lamb mortality represents significant waste to sheep farming businesses as well as impacting animal welfare.

Inadequate colostrum quality and failure of transfer of passive immunity (FTPI) puts lambs at increased risk of morbidity and mortality.

This case report presents a holistic approach to a higher than target lamb mortality on a commercial sheep flock.

KEY FINDINGS:

1 **Body condition:** Monitor (by 'hands-on' body condition scoring of 10-15% of animals from each management group at key time points throughout the production season, namely: weaning, pre-tupping, scanning and pre-lambing) in order to manage and maintain BCS and minimise any inevitable losses in condition in late pregnancy.

2 **FTPI:** 17% of the 2024 lamb crop suffered from FTPI, which increases the risk of neonatal lamb morbidity and mortality.

3 **Colostrum quality:** 40% of samples were classed as poor quality (<50g/L IgG as measured by radial immunodiffusion) and poor colostrum quality was associated with poor serum IgG (<15g/L) in the lambs.

4 **Feeding equipment hygiene:** 80% of 'point of feeding' supplementary colostrum samples failed to meet total bacterial count threshold (100,000CFU/ml) which may negatively impact lamb health.

CONTENTS

INTRODUCTION

LAMB MORTALITY IN A UK CONTEXT

The neonatal period represents a high-risk period in the life of a lamb. AHDB published industry figures in 2015 estimating lamb losses of between 5% and 30%, however there is a body of data to suggest lamb mortality has not improved since the 1970s (Dwyer et al., 2016; Gascoigne et al., 2023).

It is well established in the literature that the majority of pre-weaning lamb deaths occur within this neonatal period (Dwyer et al., 2016). There may be many risk factors for higher than desirable lamb mortality, including dystocia, weak lambs, poor mothering, hygiene at housing, predation and inadequate colostrum quality, quantity or timing of ingestion leading to failure of transfer of passive immunity (Binns et al., 2002). High lamb mortality has significant welfare consequences and myriad implications for profitability and sustainability of the farming enterprise.

TRANSFER OF PASSIVE IMMUNITY AND THE IMPORTANCE OF COLOSTRUM

The syndesmochorial structure of the ruminant placenta means that neonates are born hypogammaglobulinaemic because transplacental passage of immunoglobulins (IgG) is prevented. Lambs depend on the transfer of immunoglobulins from maternal colostrum across the neonatal gut enterocytes into their bloodstream during the first 6-18 hours after birth to provide humoral immunity against diseases during the early weeks of life (Agenbag et al., 2021).

When this process does not confer adequate immunity, the lamb is said to be suffering for Failure to Transfer Passive Immunity (FTPI). There is no universally accepted cut point to define FTPI in lambs. A serum IgG concentration of 15g/L between 24 and 48 hours after birth has been used in previous peer reviewed literature (Hamer et al., 2023). However, some authors have used other cut points. For example, Massimini et al (2006) suggested optimal IgG serum concentration to avoid FTPI in lambs was between 6-16g/L (McGuire et al., 1983). The value of 10g/L has traditionally been widely used in dairy calves although this has recently been redefined by Lombard et al. (2020). The redefinition includes four categories of serum IgG concentration: excellent, good, fair and poor, with serum IgG levels of ≥25.0, 18.0-24.9, 10.0-17.9, and <10g/L, respectively.

There is a dearth of literature on the prevalence of FTPI in lambs both in the UK and internationally. A UK study on four farms estimated the prevalence at 7.7% using the cut point of 15g/L (Hamer et al., 2023). A further case study revealed 63% of lambs suffered from FTPI as identified by indirect estimation of IgG in lamb serum using zinc sulphate turbidity (ZST) and total protein (TP) (Hamer et al., 2020). It is likely that there is wide variation in the prevalence of FTPI in lambs between farms and that FTPI prevalence depends on specific farm management (Hamer et al, 2020; Hamer et al, 2023).

COLOSTRUM: BEYOND IMMUNOGLOBULINS

Colostrum is not only a source of immunoglobulins, but also an essential energy supply for newborn lambs to support thermoregulation. Lambs have a higher surface area to bodyweight ratio than larger species and lose heat faster (Dwyer et al., 2016). Whilst internal brown fat provides much of the energy source initially, only 2-4.5% of lamb birthweight is brown fat.

Energy reserves are essential for newborn survival, especially if climatic conditions are unfavourable. Colostrum contains approximately 2-13% fat providing 2kcal of energy/ml (Nowak and Poindron, 2006). Colostrum also contains a mix of beneficial bioactive and immune modulating factors, including oligosaccharides, hormones, neutrophils, leukocytes and macrophages (Castro et al., 2011).

FARM BACKGROUND AND HISTORIC DATA

This project was carried out during March 2024 under University of Glasgow ethics licence (EA63/23) on a commercial sheep and beef farm in Scotland.

TABLE 1 FARM DESCRIPTION AND OVERALL BACKGROUND

Approximately 500 hectares
935 commercial ewes – 150 spring calving and summer/autumn calving sucklers
Lambs are sold off grass, June to September
Approximately 20 store cattle kept through the winter with most sold as suckled calves at seven to eight months in October
Pedigree Charolais herd suppling pedigree breeding bulls to other farmers

A routine herd health assessment revealed higher than expected lamb mortality rates during the 2022/23 season. In the 2022/23 production cycle, 626 ewes and hoggs were bred to the tup with a combined scanning percentage of 186% and potential lamb numbers of 1,178. At marking time in the 2022/23 season, 885 eight-week-old lambs were marked, revealing a lamb mortality percentage of 24.9% (n=293/1,178). Median lamb mortality in the first 21 days of life in the UK is quoted as being around 8% (AHDB, 2021). During lambing 2023 (2022/23 production cycle), the perinatal losses were further quantified through farmer self-reporting, via a whiteboard, detailing perceived causes of death.

Using this farmer recording system may have led to a degree of under-reporting during the busy lambing season and the recorded figures may be an underestimation of lamb losses.

TABLE 2 FARMER RECORDED REASONS FOR PERINATAL LAMB MORTALITY IN THE 2022/23 SEASON

NOTE: THESE WERE RECORDED USING A WHITEBOARD MARKING SYSTEM IN THE LAMBING SHED.

	NUMBER OF LAMBS	% LAMB LOSS
Rotten/abortion	21	13.6
Watery mouth/joint ill	27	17.5
Dystocia – e.g. backwards	43	27.9
Laid on	5	3.2
Lost in field	58	37.7
Total	**154**	**13.0**

FOOTNOTE: THE COMBINED SCANNING PERCENTAGE FOR 629 EWES AND HOGGS THIS LAMBING SEASON WAS 186%, GIVING POTENTIAL LAMB NUMBERS OF 1,178 (THE DENOMINATOR FOR TOTAL LOSS PERCENTAGE), MEANING THE 154 LAMBS RECORDED HERE IS AN UNDERESTIMATION OF TOTAL LAMB LOSSES AND SOME LAMBS WILL NOT BE ALLOCATED FARMER RECORDED REASON FOR DEATH.

PROJECT AIMS

The overall aim of this project was to identify risk factors for neonatal lamb morbidity and mortality on a commercial farm in south west Scotland. Neonatal lamb mortality in particular has been unacceptably high on this farm at 24.9% (n 293/1,178).

SPECIFIC OBJECTIVES OF THIS WORK WERE TO PROSPECTIVELY MEASURE:

- Serum IgG concentration for lambs 48 hours old and estimate prevalence of FTPI (<15g/L).
- Colostrum IgG concentration from post-partum ewes and estimate prevalence of low colostrum IgG concentration (<50g/L).
- Body condition scores and nutritional inputs of ewes throughout production cycle 2023/2024.
- Bacterial contamination of ewe colostrum at point of feeding to lambs as a secondary (to IgG) quality measure.

FURTHER AIMS WERE TO:

- To develop SMART goals to achieve tangible on-farm change.
- To extend message research outcomes to both farmers and vets through farming press and peer-reviewed publications.

METHODOLOGY

ON-FARM DATA COLLECTION

SCANNING

Ewe pregnancy data was obtained from farm records after scanning was completed in December 2023.

BODY CONDITION SCORING (BCS)

BCS was aligned with key production cycle stages. All BCS carried out by one of two trained veterinary surgeons using the protocol detailed in Appendix A (see supplementary material).

KEY PRODUCTION STAGES DEFINED AS:

1. Pre-tupping
2. Scanning
3. Late gestation
4. Lambing
5. Weaning

METABOLIC PROFILING AND NUTRITIONAL ANALYSIS

Ewe blood samples were collected 10 days before the start of lambing from 10 multiple pregnancy ewes (carrying twins and triplets) ewes to determine whether the diet was meeting the immediate nutritional requirements of the ewes. Ten late lambers and hoggs were also blood sampled four weeks pre-lambing.

The ideal time to assess nutrition and metabolic status of ewes is two to three weeks pre-lambing to capture the period of peak metabolic stress and allow time for diet adjustments. Late lambers and hoggs were sampled slightly out with this window, to fit in with daily farm management tasks. Blood samples were tested for beta-hydroxybutyrate (BHB), urea-N, albumin, magnesium and copper in all cases by Dairy Herd Health and Productivity Service, University of Edinburgh.

Alongside this, feed presentation and surface area and quality of the feed face were visually assessed, and silage was analysed by SAC Analytical Services.

COLOSTRUM AND SERUM SAMPLE COLLECTION

All ewes 'actively lambing' at the time of researchers' farm visits were eligible for enrolment in the project (in order to collect pre-suckle colostrum samples). Lambs born to these ewes were then eligible for blood sampling two days later, therefore, lambs enrolled for blood sampling were dependent on ewe enrolment and colostrum sampling. Visits were conducted at convenience to daily routine and typically occurred between 5.30am and 7pm by one of two veterinary surgeons (with a working knowledge of the farm) from 11th to 30th March 2024.

FURTHER INFORMATION COLLECTED INCLUDED:

1. Ewe and lamb ID
2. Litter size (single and multiple pregnancies)
3. Lamb birthweight
4. Lambing assisted or unassisted (if known)
5. Ewe BCS (see Appendix A)

All pre-suckle colostrum samples were collected from the teats of the freshly lambed ewes and 48 hours after colostrum sampling the ewe's lambs were blood sampled. A convenient selection of colostrum samples from feeding equipment at the point of feeding and storage containers were collected throughout the lambing period before the colostrum in these containers was fed to newborn lambs. Blood samples (2ml) were collected by jugular venepuncture using a 20-gauge, one-inch needle into 5ml vacutainers without anticoagulant. Blood samples were chilled immediately after collection and allowed to clot. Samples were separated using a centrifuge (Microcentrifuge B0CC4WXJ94, China) and serum was frozen at -20°C in a temperature-monitored freezer (Elitech RC 5+, Elitech, London) until further testing at the University of Glasgow internal laboratories.

LABORATORY TESTING

Serum and colostrum samples were thawed at room temperature and vortexed (Vortex Genie 2, Scientific Industries Inc, USA) prior to testing.

COLOSTRUM AND SERUM IGG CONCENTRATIONS

Colostrum IgG and serum IgG concentrations were directly measured using radial immunodiffusion (RID) plates (Triple J Farms, Bellingham, USA). Colostrum samples were diluted 1:3 with phosphate-buffered saline and serum samples were diluted 1:1. Five µL of each of the diluted serum and colostrum samples were pipetted into each sample well. Plates were incubated at room temperature (24°C) in a moist chamber for 24 hours, after which time the zones of diffusion were measured using using digital vernier callipers (IP54 Water-resistant Louisware electronic, accuracy 0.01mm, range 0-150mm). Five µL of each manufacturer provided standard sera (plus two extra standards created by diluting the provided standards) were pipetted into sample wells in order to make a reference curve, against which sample IgG concentrations were determined.

The zonal diffusion measurements for a set of standard sera were squared and plotted against the IgG concentrations. All samples were tested in duplicate, and a mean measurement for each sample was calculated. The Intra-assay Coefficient of Variation was calculated.

Figure 1: An example of the radial immunodiffusion plates showing the zonal diffusion of the concentric rings to allow IgG concentrations to be determined.

Figure 2: Colostrum samples undergoing bacteriology testing at the laboratories at the School of Biodiversity, One Health and Veterinary Medicine, University of Glasgow.

COLOSTRUM BACTERIAL CONTAMINATION

The same colostrum samples (as those measured using RID plates) were simultaneously tested using aerobic count (ACP) and coliform count (CCP) Petrifilms (3M, St. Paul, MN).

The Petrifilms were diluted and 1:3,250 for total bacterial counts and 1:125 for total coliform counts according to the protocol outlined by Moore and Sischo (2015). CCP were incubated for 24 hours at 35°C+/-2°C and ACP were incubated at 32°C+/-2°C for 48 hours, each in stacks of no more than 20 films. Petrifilms were read depending on the number of colonies per grid square, according to manufacturer instructions and following the SOP published by Moore and Sischo (2015).

Briefly, if Petrifilms had more than 100 colonies, three representative squares on the film were selected and the average the number of colonies in those three squares calculated. This average figure was then multiplied by the dilution factor.

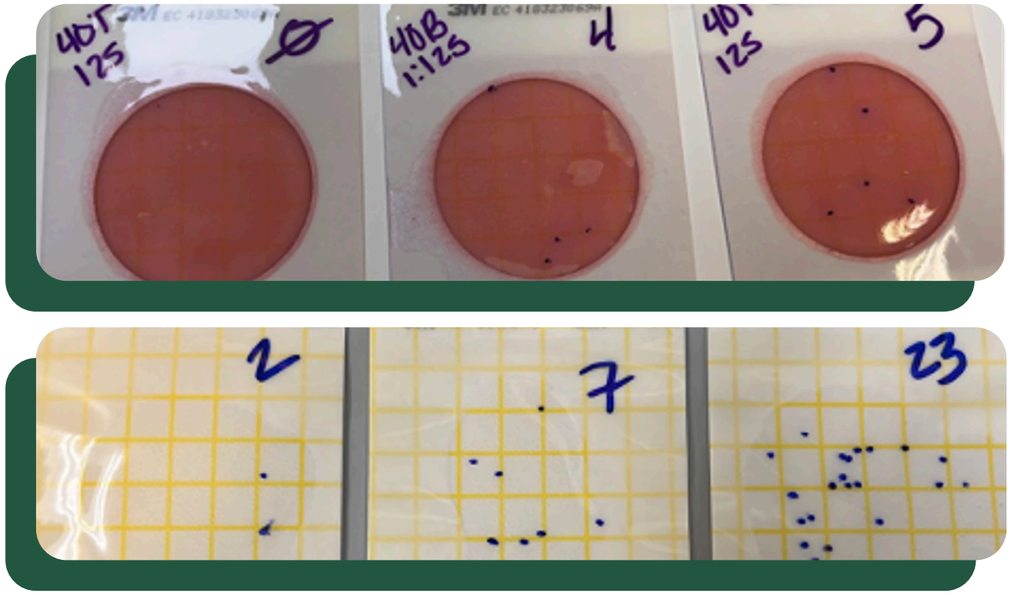


Figure 3: Examples of Petrifilms used to measure colostrum bacterial contamination at the laboratories at the School of Biodiversity, One Health and Veterinary Medicine, University of Glasgow.

STATISTICAL ANALYSIS

All data was input in Excel (Microsoft, version 16.89) and data was analysed using Stata statistical software (StataCorp LLC version 17).

DESCRIPTIVE STATISTICS

Descriptive statistics were calculated for body condition scores, serum and colostrum IgG measures and bacterial contamination measures. Box and whisker plots were constructed to explore the trends in BCS throughout the production cycle. A one-way repeated measures ANOVA was conducted to determine if there was a difference in BCS between each production cycle stage. Multilevel linear regression models were constructed to explore risk factor variables, from information gathered at lambing time (lamb burden, lamb birthweight, assisted or unassisted lambing, colostrum quality measures, ewe BCS), associated with serum IgG concentration. Univariable models for each risk factor variable were constructed and significance for inclusion in further modelling was declared at $P \leq 0.2$. Only biologically plausible risk factors were included, interaction terms and confounding variables were explored. Risk factors were excluded from multivariable modelling using a backwards, stepwise elimination process and the likelihood ratio test was used to compare the models ($P<0.05$). Standardised residual plots and outliers were examined for all final models to determine model fit, and residuals were found to lie within 2 SD of the predicted values for all final models.

RESULTS

SCANNING

Scanning data from 31st December 2023 is shown in Table 3 below.

TABLE 3 SCANNING RESULTS FROM DECEMBER 2023 DEMONSTRATING THE FLOCK'S MAXIMUM POTENTIAL FOR LAMBING 2024

GROUP ID	LITTER SIZE						TOTAL EWES (N)	LAMBING %	INDUSTRY KPI
	Empty	1	2	3	4	5			
Total ewes	27	147	489	110	9	2	784	191	
Total hoggs	26	61	62	2	0	0	151	126	
Total ewes and hoggs	53	208	551	112	9	2	935	181 (n=2,592 lambs)	180+

BODY CONDITION SCORING

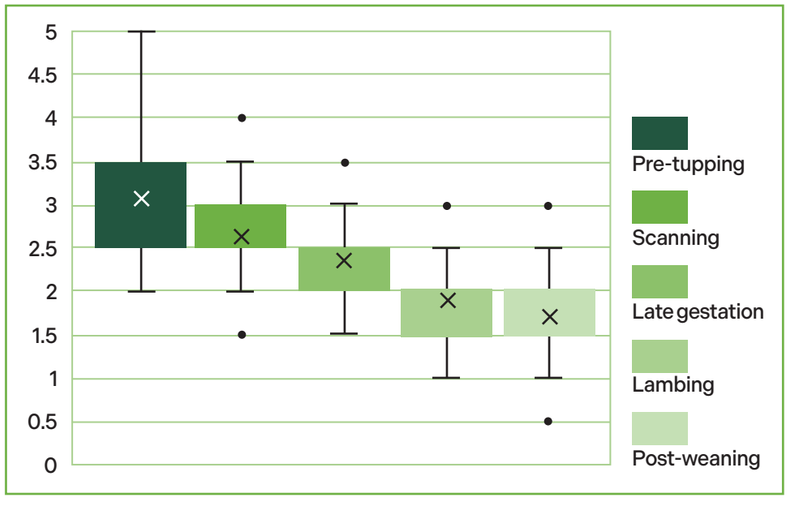
Descriptive statistics of BCS throughout season 2023/24 are shown in Table 4 alongside the number of animals scored on each occasion as a percentage of the total flock numbers. Target body condition scoring was determined by industry target and farmer desire and opinion of what was possible within the farming system.

TABLE 4 BCS DATA FOR THE PRODUCTION CYCLE 2023/24, AS DETERMINED BY ONE OF TWO FARM VETERINARY SURGEONS, SHOWING THE CHANGE AND ABSOLUTE DECREASE IN BCS FROM TUPPING TO WEANING AT KEY PRODUCTION CYCLE STAGES

	% OF FLOCK SCORED (N)	MEAN	MAX.	MIN.	STD DEV	TARGET BCS FOR PRODUCTION CYCLE STAGE	% OF SCORED ANIMALS ACHIEVING TARGET BCS
Pre-tupping (September 2023)	24.7% (231/935)	3.1	5.0	2.0	0.6	2.5/3.0	55% (128/231)
Scanning (December 2023)	30.8% (288/935)	2.6	4.0	1.5	0.5	2.5/3.0	73% (210/288)
Late gestation (January 2024)	19.5% (182/935)	2.4	1.5	3.5	0.5	2.5/3.0	56% (102/182)
Lambing (March/April 2024)	10.5% (98/935)	1.9	3.0	1.0	0.4	2.5	21% (21/98)
Post-weaning (July 2024)	34.2% (320/935)	1.7	3.0	0.5	0.4	2.0/2.5	45% (143/320)

FOOTNOTE: THE SCORES CONTRIBUTING TO THE NUMERATOR FOR THE % OF ANIMALS ACHIEVING DESIRED SCORED IS SHOWN IN COLUMN 'TARGET BCS FOR PRODUCTION CYCLE'. TARGET BCS IS A COMBINATION OF INDUSTRY TARGET AND FARMER DESIRE AND OPINION OF WHAT IS POSSIBLE WITHIN THE FARMING SYSTEM. ONE-WAY REPEATED MEASURES ANOVA SHOWED A STATISTICALLY SIGNIFICANT DIFFERENCE BETWEEN THE MEAN BCS AT EACH PRODUCTION CYCLE STAGE (PRE-TUPPING, SCANNING, LATE GESTATION, LAMBING, POST-WEANING), F = (3,116) 157.67, P<0.01.

FIGURE 4 BOX AND WHISKER PLOTS OF BCS FOR PRODUCTION CYCLE STAGE 2023/24



*FOOTNOTE: THE SHAPE OF THE BOXPLOT SHOWS HOW THE DATA IS DISTRIBUTED WITH THE WHISKERS REPRESENTING THE RANGE FOR THE TOP AND BOTTOM QUARTILES. THE MEAN IS MARKED BY **X**, OUTLIERS MARKED BY ●*

METABOLIC PROFILING

Metabolic profile results are shown in Table 5. BHB is used as a biomarker, indicating mobilising body energy reserves and excessive negative energy balance. Ewes carrying multiple lambs 10 days pre-lambing were failed to have their energy requirements met, as illustrated by 50% of the samples from these animals having elevated B-hydroxybutyrates (>1.00mmol/L).

Energy requirements of second cycle ewes and hoggs were adequately met four weeks pre-lambing. However, the adequacy of diets should ideally be assessed two to three weeks pre-lambing, as this is the period of peak metabolic stress.

Albumin is a protein produced by the liver. Low concentrations are of particular concern, as they may be associated with liver damage from e.g. fluke, blood loss from e.g. haemonchosis infection, chronic disease or chronic under-supply of protein in the diet. A cut point of 30g/L was used for albumin concentrations and 40% of samples were marginally low in the ewes in the multiple pregnancy group.

Liver damage or blood loss would likely result in very low albumin (<15-20g/L, below 'marginal' status) and so the possibility of such disease was less likely was in these animals.

The results were interpreted to indicate that the long-term protein status of the groups was good, despite marginal albumin concentrations. Late lambers and hoggs had albumins above the cut point (30mmol/L) at individual and group level. Urea-N indicates the short-term protein status of the groups and daily intakes of Effective Rumen Degradable Protein (ERDP).

This was considered good in both groups since Urea-N results were above the threshold of 1.7mmol/L and the group mean was 3.49mmol/L in the ewes carrying multiple lambs and 3.76mmol/L in the late lambers and hoggs. Magnesium and copper concentrations were adequate in both groups.

FEED AVAILABILITY

The feed space available was 2,667cm divided into seven 381cm sections with approximately 50 ewes on average with access to each of these sections.

This gave an approximate space of 7cm/ewe.

Feed barrier design was open fronted with trough and triple horizontal bar to prevent escape. At this stage, the TMR was fed once daily.

Figure 5: Ewes grouped from lambing showing the feed barrier design at which ad lib TMR was available.

TABLE 5 METABOLIC PROFILING RESULTS FOR TWINS AND TRIPLETS 10 DAYS PRE-LAMBING AND THE LATE EWES AND HOGGS THREE TO FOUR WEEKS PRE-LAMBING

TWINS AND TRIPLETS	1	2	3	4	5	6	7	8	9	10	MEAN	% OF SAMPLES FAILING TO MEET CUT POINT[1] (N)
BHB (mmol/L)	1.08	1.57	0.46	0.40	0.37	2.57	1.22	0.83	0.80	1.06	1.04	50 (5/10)
Urea-N (mmol/L)	4.33	3.98	3.16	3.96	3.17	2.55	3.05	3.67	2.87	4.20	3.49	0 (0/10)
Alb (g/L)	31.70	30.00	29.10	31.00	33.20	37.00	28.60	49.40	29.00	29.30	32.83	40 (4/10)
Mg (mmol/L)	0.96	1.25	1.21	1.07	1.08	0.84	0.81	1.07	1.03	1.06	1.04	0 (0/10)
Cu (umol/L)	14.65	17.71	14.64	13.79	16.40	15.68	15.60	13.25	14.12	13.71	14.96	0 (0/10)
Diet at time of sampling	Housed on TMR: ~3kg/head of silage[2], 0.2kg/head of pot black, 0.5kg/head 18% ewe rolls and high energy licks											

LATE EWES AND HOGGS	1	2	3	4	5	6	7	8	9	10	MEAN	% OF SAMPLES FAILING TO MEET CUT POINT (N)
BHB (mmol/L)	0.79	0.50	0.32	0.44	0.56	0.35	0.37	0.62	0.63	0.47	0.51	0 (0/10)
Urea-N (mmol/L)	3.62	2.88	6.33	3.77	3.11	2.46	4.56	4.10	4.26	2.50	3.76	0 (0/10)
Alb (g/L)	41.90	40.10	37.70	43.50	39.60	44.30	46.80	28.90	40.60	43.80	40.72	10 (1/10)
Mg (mmol/L)	0.99	0.93	1.30	0.96	1.03	1.05	1.08	0.95	0.93	0.84	1.01	0 (0/10)
Cu (umol/L)	17.61	17.87	18.90	14.92	15.56	17.91	-	14.57	14.50	14.00	16.20	0 (0/10)
Diet at time of sampling	Managed outside still on ad lib big bale silage and access to licks											

NOTE: SAMPLES IN RED SHOW SAMPLES FAILING TO MEET THE CUT POINT; [1]BETA-HYDROXYBUTYRATE CUT POINT = 1.0MMOL/L; UREA-N CUT POINT = 1.7MMOL/L; ALBUMIN CUT POINT = 30G/L; MAGNESIUM REFERENCE RANGE = 0.7-1.3MMOL/L; COPPER REFERENCE RANGE = 9.40-19UMOL/L; [2]ANALYSIS IN SUPPLEMENTARY MATERIAL: APPENDIX D.

COLOSTRUM AND SERUM IGG CONCENTRATION

A total of 85 colostrum samples and 78 serum samples were available for analysis. Seventy-six were 'matched' colostrum and serum samples. Fifteen conveniently collected colostrum samples from feeding equipment at the point of feeding and storage containers were available for analysis.

Table 6 shows the descriptive statistics of colostrum IgG concentration and the percentage of samples failing to meet the acceptable IgG concentration threshold (>=50g/L).

TABLE 6 DESCRIPTIVE STATISTICS FOR COLOSTRUM IGG CONCENTRATION OF PRE-SUCKLED COLOSTRUM FROM 85 EWES DURING THE LAMBING PERIOD 2024

	N SAMPLES	MEAN	ST DEV	MIN.	MAX.	% SAMPLES FAILING INDUSTRY THRESHOLDS (N)
Colostrum (teat) IgG (g/L)	85	54.28	19.08	12.83	87.96	40% (34/85)

Table 7 shows the descriptive statistics of serum IgG concentration and the percentage of samples failing to meet acceptable IgG concentration threshold (>=15g/L); 18% of lamb serum samples (n=13/78) were found to be below the threshold of 15 g/L and these lambs would be classed as having FTPI.

TABLE 7 DESCRIPTIVE STATISTICS FOR SERUM IGG CONCENTRATION OF PRE-SUCKLED COLOSTRUM FROM 78 EWES DURING THE LAMBING PERIOD 2024

	N SAMPLES	MEAN	STD DEV	MIN.	MAX.	% SAMPLES CLASSIFIED AS FAILED PASSIVE IMMUNITY (<15G/L)
Serum IgG (g/L)	78	31.37	14.38	1.51	67.97	17.95 % (14/78)

The RID intra-assay coefficient of variation (CV) for serum averaged 2.55% and for colostrum 2.09% averaged 2.09% indicating that the RID test was repeatable and accurate.

RELATIONSHIP BETWEEN EWE COLOSTRUM AND LAMB SERUM IGG CONCENTRATION

Figure 6 shows the scatter relationship between colostrum IgG concentration and serum IgG concentration. Serum IgG concentrations was statistically significantly associated with colostrum IgG concentration (Table 8).

FIGURE 6 SCATTER PLOT OF 76 'MATCHED' EWE COLOSTRUM IGG (G/L) AND LAMB SERUM IGG (G/L) AS MEASURED BY RADIAL IMMUNODIFFUSION TESTING DURING THE 2023/24 SEASON

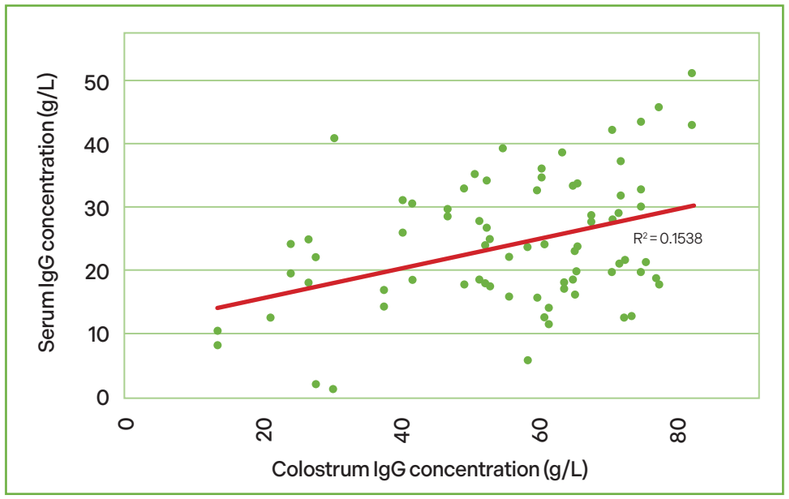
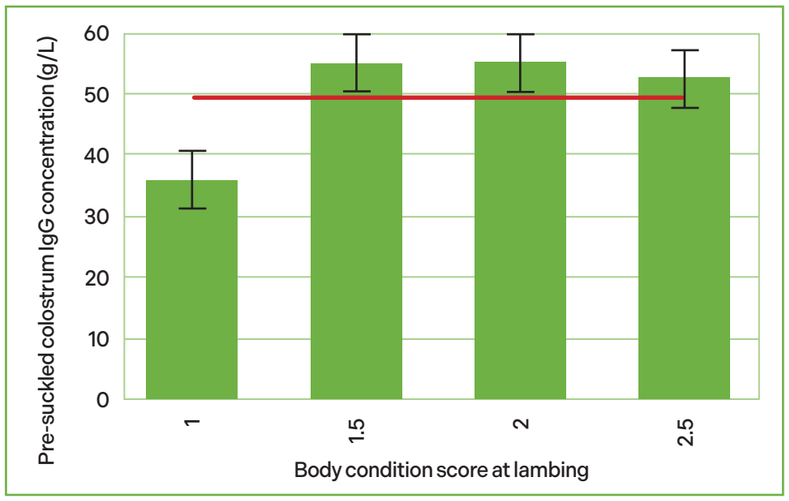


TABLE 8 FINAL MULTIVARIABLE LINEAR MODELS FOR RISK FACTOR VARIABLES SIGNIFICANTLY ASSOCIATED (P<0.05) WITH SERUM RID (G/L) FROM 76 LAMB SERUM SAMPLES COLLECTED DURING LAMBING 2024 WITH EWE INCLUDED AS A RANDOM EFFECT

OUTCOME VARIABLE	PREDICTOR VARIABLE	CO-EFFICIENT	95% CI	P-VALUE
Serum IgG (g/L)	Colostrum IgG (g/L)	0.22	0.10-0.35	<0.01

From this dataset, a graphical relationship between body condition score at lambing and mean colostrum IgG concentration was observed with lower body condition score animals associated with poorer quality (low IgG concentration <50g/L) colostrum (Figure 7). However, it is important to note that this observation was not statistically significant (p=0.9).

FIGURE 7 BCS AT LAMBING OF 85 EWES COMPARED WITH THE MEAN COLOSTRUM IGG CONCENTRATION (G/L) FROM THOSE EWES



FOOTNOTE: THE RED LINE INDICATES THE INDUSTRY ACCEPTED CUT POINT (50 G/L) OF ACCEPTABLE COLOSTRUM IGG CONCENTRATION.

COLOSTRUM BACTERIOLOGY

Acceptable bacteriology cut points for colostrum are extrapolated from the dairy industry and defined as 100,000CFU/ml for total bacteria counts (TBC) and 10,000CFU/ml for total coliform counts (TCC). Table 9 presents the descriptive statistics for colostrum TBC and TCC, along with the percentage of samples that failed to meet the industry standards for TBC and TCC. The data includes several (n=15) conveniently collected colostrum samples collected both directly from the ewe's teat and from the feeders before the colostrum was fed to lambs that required colostrum supplementation.

TABLE 9 DESCRIPTIVE STATISTICS FOR COLOSTRUM BACTERIOLOGY (TOTAL BACTERIA COUNT [TBC] AND TOTAL COLIFORM COUNT [TCC]) FROM TEAT SAMPLES (PRE-SUCKLED, N=85) AND FEEDER SAMPLES (AT 'POINT OF FEEDING', N=15) DURING THE 2023/24 LAMBING SEASON

	N SAMPLES	MEDIAN	IQR	ST DEV	MIN.	MAX.	% SAMPLES FAILING INDUSTRY THRESHOLDS (N)
Colostrum (teat)							
TBC (CFU/ml)	85	6,500	34,375	0.9x107	0	0.45x107	18.82 (16/85)
TCC (CFU/ml)	85	0	0	686.05	0	4,500	00.00 (0/85)
Colostrum (feeder/store)							
TBC (CFU/ml)	15	0.11x107	0.24x107	0.15x107	0	0.47x107	80.00 (12/15)
TCC (CFU/ml)	15	32,500	69,000	40,212.4	0	123,250	66.67 (10/15)

Figure 8: Example of colostrum storage bucket used at lambing time for 'orphan' lambs or lambs requiring supplementary colostrum during the 2023/24 lambing season.

DISCUSSION

BODY CONDITION SCORING

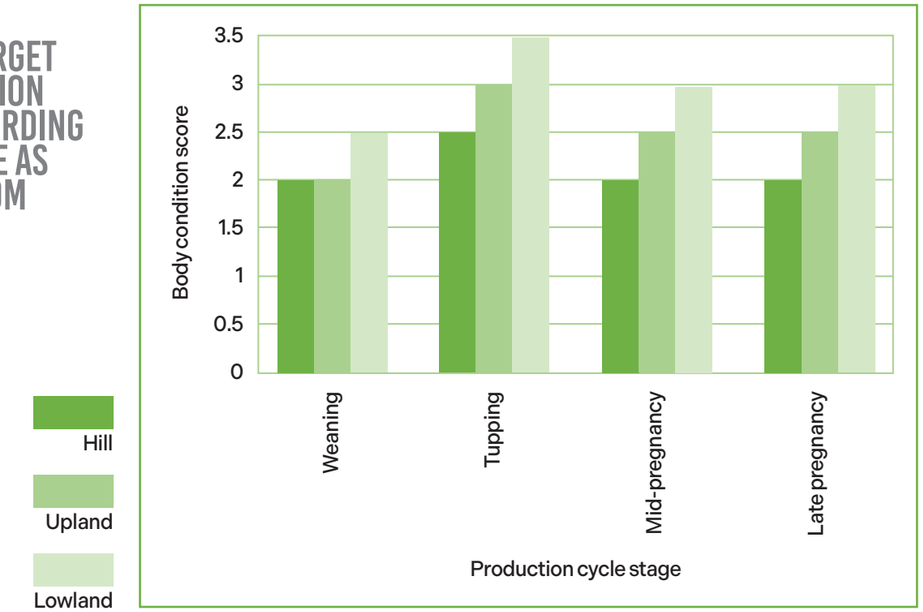
BCS systematically assesses body fat reserves of an adult sheep. Changes in BCS in late gestation (particularly excessive loss of BCS) has been associated with lower colostrum volume and quality, poor foetal growth (leading to lower lamb birthweights), increased risk of health issues, e.g. twin lamb disease, and less milk production.

Furthermore, Dwyer et al. (2003) observed that even ewes experiencing moderate undernutrition exhibited suboptimal maternal behaviour, resulting in a diminished ewe-lamb bond. The risk of ewes losing body condition in late gestation is twofold.

Firstly, the energy needs of both the ewe and the foetus increase significantly. Secondly, the ewe's dry matter intake decreases as the growing foetus occupies more space in the abdomen, physically limiting the capacity for food consumption.

By body condition scoring ewes at key production cycle stages, namely pre-tupping, scanning, late gestation, lambing and post-weaning, producers are able to monitor BCS changes and manage their ewes' reserves (AHDB, 2019). The recommended BCS for farm type is shown in Figure 9.

FIGURE 9 INDUSTRY TARGET BODY CONDITION SCORES ACCORDING TO FARM TYPE AS ADAPTED FROM AHDB (2019)



METABOLIC PROFILING

Swanson et al. (2008) reported that inadequate nutrition from mid to late pregnancy in ewes impacts the quality and quantity of colostrum, which is likely to negatively affect lamb health and survival in the neonatal period. Metabolic profiling revealed ewes were not receiving adequate energy to meet their maintenance and metabolic requirements, since 50% of samples showed elevated BHBs (>1.0mmol/L).

The calculated and formulated ewe ration on this farm should have met energy requirements for 70-80kg ewes in late gestation, however feed access is a key component for the success of the late gestation diet. AHDB recommends 15cm/ewe on an ab lib forage or TMR diet (AHDB, 2019).

Ewes had around 7cm/ewe and the TMR was delivered once daily. Approximately 550 ewes lambed in a two-week period in lambing 2024 according to farm records. Feed access will have contributed to ewes struggling for energy. Based on the metabolic profiling results, TMR feeding was increased to twice daily to ensure food was always available and to reduce competition, given the limited space at the feeding area.

Planned expansion of lambing facilities into polytunnels should alleviate pressure on the existing lambing shed with concurrent proposed increases in flock numbers (from around 600 in 2022 to 930-1,000 in 2024 onwards). This plan is intended to be actioned for lambing 2025. More accurate measures for ewe accommodation and feed access are required to maximise production and body condition score (using the 15cm/ewe targets described above as a guideline for feed access space).

COLOSTRUM AND SERUM IGG CONCENTRATION

The cut point for acceptable colostrum quality was 50g/L to maximise transfer of IgG to lamb serum (Hamer et al., 2023). Whilst this threshold is extrapolated from cattle it allows for situations where volume of colostrum being produced or lamb intake ability may be limited. By demanding an increase in concentration of IgG, a larger mass of IgG is available for passive transfer. Another suggested cut point of acceptable colostrum quality in the literature, 20g/L, do not take this into account (Kessler et al., 2021). A total of 40% of samples failed to meet the threshold for 'acceptable' quality colostrum (>50g/L). Page et al. (2022) found 24% of samples from 64 flocks failed to meet the threshold for 'acceptable quality'. However, Hamer et al. (2023) only found a prevalence of inadequate colostrum quality, in terms of IgG concentration, of 4.5%, from four farms. Although peer-reviewed publications on the prevalence of inadequate colostrum quality are limited, it is evident that significant variation likely exists between different flocks.

Colostrum IgG concentration is influenced by change in BCS during late gestation as well as ewe breed type (Campion et al., 2019). Only 56% of the assessed flock attained the target body condition score (BCS) of 2.5-3.0 during late gestation. This percentage further declined to just 21% by the time of lambing. Attention to maintaining appropriate BCS is likely to reap benefits in terms of better colostrum IgG concentration.

Approximately one in six lambs suffered FTPI during lambing 2023 at the serum IgG cut point of 15g/L. Risk factors for FTPI are multifactorial and summarised in Table 10 and involve lamb, ewe and farm influences (Dwyer et al., 2016).

TABLE 10 RISK FACTORS ASSOCIATED WITH FTPI IN EWES (DWYER ET AL., 2016)

LAMB FACTORS	EWE FACTORS	FARM FACTORS
Prematurity	Breed and genetics	Poor management practices
Weak lambs	Late gestation nutrition	Delayed intervention
Low birthweight	BCS	Inadequate monitoring
Hypothermia	Health issues e.g. chronic fluke	Overstocking in lambing accommodation
Dystocia	Age – ewe lambs or gimmers	Hygiene
	Maternal behaviour and bond	Stress
	Multiple births	

In combination with the holistic approach taken throughout this case study, key risk factors were identified as primarily ewe and farm factors. Specifically, ewe BCS and nutrition in late gestation, lambing accommodation and stocking density affecting maternal behaviour and bond, and hygiene of lambing shed.

RELATIONSHIP BETWEEN EWE COLOSTRUM AND LAMB SERUM IGG CONCENTRATION

There was a statistically significant, positive associated between ewe colostrum IgG concentration and serum IgG concentration. This is similar to the findings found by Hamer et al. (2023), p=0.02. This further supports the necessity for attention to detail to optimise ewe BCS and manage pre-lambing nutrition to enhance colostrum IgG levels, which would be expected to yield benefits in terms of increased lamb serum IgG and consequently reduced prevalence of FTPI.

COLOSTRUM BACTERIOLOGY

To the authors' knowledge, this case study is the first in the UK to look at colostrum cleanliness at the point of feeding and colostrum stores at lambing time. Some work has been done investigating colostrum contamination on UK dairy farms.

Hyde et al. (2020) found 29.6% of all samples collected exceeded the recommended TBC threshold (>100,000CFU/ml). Haggerty (2021) found 30.6% of point-of-feeding samples failed to meet industry TBC threshold. On sheep farms, lambs are expected to stand, suckle quickly and naturally consume colostrum to ensure proper transfer of passive immunity.

However, if this does not occur and intervention is necessary, we must supplement with colostrum. In doing so, it is crucial to avoid causing unintentional harm by feeding colostrum that may be heavily contaminated; 80% of feeder and store samples failed TBC threshold and 66% of feeder and store samples failed TCC thresholds in the current work. High bacterial counts in colostrum may impair absorption of antibodies from colostrum even if colostrum antibody concentration is high (greater than 50g/L).

MECHANISMS:

In particular, coliform species (which are ubiquitous in farming environments) have been shown to impair IgG absorption by a number of mechanisms:

1. Bacteria physically bind to antibody within the gastrointestinal lumen, blocking uptake across enterocytes.
2. Pathogenic bacteria, such as E. coli, Salmonella spp, attach and damage intestinal cells, reducing gut permeability.
3. Pathogenic bacteria damage intestinal cells, accelerating gut closure and impermeability to large molecules – namely immunoglobulins.
4. Bacteria physically block antibody molecule absorption channels.

(Corley et al., 1977; James et al., 1981; Staley and Bush, 1985)

TENSION FOR CHANGE

INCLUDING SMART GOALS AND ACTION PLAN FOR THE FARM

MONITORING AND FLOCK HEALTH PRINCIPLES

1. Focus on minimising BCS change, particularly in late gestation

a. Poppy Frater, SAC Consulting has consulted on: Improving the flock efficiency and advised regarding nutrition management post-scanning 2024.
b. Maintain 2.5/3.0 from scanning to late gestation aiming for >80% of the flock to be in BCS 2.5 at lambing.
c. Page et al. (2022) found that flock level management decisions had the biggest impact on colostrum quality.

2. Focus on nutrition and feed access

a. Increase feed access in housed ewe during late gestation and at the point of lambing towards AHDB recommended target of 15cm/ewe for as lib TMR. Accurate measurements of feed space and stocking density are required.
b. Planned expansion of lambing facilities (polytunnels) for production cycle 2024/25. Again, measure these to maximise gains.

3. Review of colostrum supplementation policy

a. Try to minimise the number of lambs routinely supplemented with colostrum in lambing 2025.
b. Priority should be to encourage lambs to suckle the ewe directly as this is the most hygienic way to deliver colostrum to the neonate and promotes maternal bonding.

4. Review of colostrum storage and equipment hygiene

a. Clean all storage and feeding equipment thoroughly with a scrubbing brush, detergent and hot water after every use in case you need to use the equipment (minority of lambs).
b. Purchase multiple feeders to allow for thorough cleaning after every use.
c. Chill colostrum at 4°C (for up to two days) if not fed immediately to prevent bacterial proliferation. Alternatively freeze excess colostrum at -20°C for up to six months (thaw in hot water bath before feeding).
d. Ewe colostrum is always best for supplementation if can be stored appropriately – frozen promptly after collection and defrosting in a warm water bath.
e. Consideration could be given to a good quality colostrum replacer that can be made up as required, as opposed to prolonged colostrum storage at room temperature.

SUPPLEMENTARY MATERIAL

APPENDIX A: BCS PROTOCOL

REFERENCE: AHDB BETTER RETURNS

Score 1: The spinous and transverse processes are prominent and sharp. The fingers can be pushed easily below the transverse bone and each process can be felt. The loin is thin with no fat cover.

Score 2: The spinous processes are prominent, but smooth, individual processes being felt only as corrugations. The transverse processes are smooth and rounded, but it is still possible to press fingers underneath. The loin muscle is a moderate depth, but with little fat cover.

Score 3: The spinous processes are smooth and rounded; the bone is only felt with pressure. The transverse processes are also smooth and well-covered, hard pressure is required with the fingers to find the ends. The loin muscle is full and with moderate fat cover.

Score 4: The spinous processes are only detectable as a line. The ends of the transverse processes cannot be felt. The loin muscles are full and rounded and have a thick covering of fat.

Score 5: The spinous and transverse processes cannot be detected even with pressure; there is a dimple in the fat layers where the processes should be. The loin muscles are very full and covered with very thick fat.

APPENDIX B: COLOSTRUM COLLECTION PROTOCOL

1. Teats were cleaned using alcohol wipes.
2. Wear gloves.
3. Open the sample container without touching the inside of the lid or the inside of container.
4. Do not place the lid of the sample container down, hold it carefully without touching the inside of the lid.
5. Collect colostrum from the teat by holding the colostrum sample container at a 45-degree angle and squirting the colostrum from the teat in the container (10ml required).
6. Put the lid on the container.
7. Label every container with date and ewe eartag.
8. After collection store, all colostrum was placed in cool box before stored in sample freezer as soon as possible after collection window.

APPENDIX C: SILAGE ANALYSIS

Feeding value

	Determination	Result	Units	Low — High
#	Dry matter	250	g/kg	
#	D value	69.6	%	
	ME	11.1	MJ/kg DM	
#	Crude protein	135	g/kg DM	
#	NDF	452	g/kg DM	
#	SIP	97	g DM/kg LW^0.75	
	Sugars	56	g/kg DM	
	Ash	84	g/kg DM	
	Oil	36	g/kg DM	

Fermentation characteristics

Lactic acid	96.4	g/kg DM	
*VFA	42.0	g/kg DM	
PAL	895	Meq/kg DM	
pH	3.9		

Degradability characteristics

	s	a	b	c
Dry matter	0.27	0.34	0.57	0.036
Nitrogen	0.58	0.68	0.23	0.079

*NOTE: * = GRAPH AS A PROPORTION OF TOTAL ACID.*

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