Case report: Failure of passive transfer and neonatal infections in a cohort of lambs

Abstract

This case report details an outbreak of neonatal lamb deaths, in which 84 of the 1203 potential lambs (from scanning) died and 70 developed septic polyarthritis, was investigated on a Scottish lowland flock of 650 breeding ewes, with good lambing-time hygiene. Poor ewe nutrition was suspected to have led to poor colostrum quality or quantity, resulting in failure of passive transfer of immunity in lambs. Ewe body condition at lambing was poor, with low blood urea nitrogen and albumin levels in pre-lambing ewe metabolic blood profiles.

Keywords

Colostrum, Lambing, Failure of passive transfer, Ewe nutrition, Neonate

Key points

Regular monitoring of ewe BCS in pregnancy is vital, with action taken if the results are outside of expected values.

Nutritional planning and dietary calculations for pregnant ewes should be undertaken prior to the risk period, i.e. the final eight weeks before lambing.

Metabolic profiles are only of use when combined with other clinical information, such as BCS, and when acted upon with the help of nutritional advice.

Investigation of clinical scenarios is essential in order to implement targeted preventative measures and encourage responsible use of antibiotics.

Background

Lamb mortality is an important contributor to production loss on sheep farms and is a welfare concern for the lambs. Variation between farms is huge, an international review found that neonatal losses can range from less than 2% up to 50% (Dwyer et al. 2016). Of which neonatal infections have been found to be a significant contributing factor (Wiener et al. 1983; Huffman et al. 1985; Green and Morgan 1993; Holmøy et al. 2017). Links between lamb mortality and failure of passive transfer of immunity (FPT) have been made (Sawyer et al. 1977), due to the near agammaglobulinaemic nature of lambs at birth (Maden et al. 2003). However, the risk factors for FTP and neonatal lamb deaths are multifactorial, depending on lamb, ewe and farm factors (Christley et al. 2003; Dwyer et al. 2016). As such, the blanket use of antibiotic medications in new-born lambs has become prevalent, with concerns that this could potentially increase selection pressure for antibiotic resistance (Priestley 2018). Therefore investigation of the cause of lamb mortality and underlying risk factors on farms is necessary to improving lamb survival without excessive antibiotic use.

Case presentation

Over a two-day period, in the first week of lambing, four 4- to 5-day old lambs presented with weakness and unresponsiveness. A total of 10 out of 150 lambs died in this first week. The lambs were treated with amoxicillin (Betamox 150mg/ml, Norbrook) and meloxicam (Metacam 20mg/ml, Boehringer Ingelheim Ltd), without any response and were therefore euthanased. Veterinary input was sought immediately, nevertheless over the following three weeks 30 lambs died with suspected neonatal infection, and over the following two months approximately 70 lambs were treated or euthanased for septic polyarthritis.

This was a 650 breeding ewe lowland mule flock in South East Scotland, managed in conjunction with a beef suckler herd. The ewes were mated with Texel rams in the autumn of 2016, the majority of ewes lambed between 1st April 2017 and 5th May. At scanning there were 1203 potential lambs, but 24 of these were born dead. All adult sheep on this farm tested negative for Border Disease Virus in 2016 and no other sheep flocks immediately neighboured the farm.

Ewe body condition scores (BCS) were below target at breeding in 2016 (Table 1; Figure 1). BCS were maintained until the ewes were scanned for pregnancy in February 2017, then decreased between February and April (Table 1; Figure 1).

Table 1: Ewe body condition scores recorded between 2016 and 2017 (graded out of 5), BCS was recorded for all ewes.

	Minimum	Mean	Maximum	Target
Pre-breeding (October 2016)	2.0	2.8	3.75	3.0 – 3.5
Scanning (February 2017)	2.75	2.9	3.5	3.0
Lambing (April 2017)	0.5	1.73	3.0	2.5 – 3.0

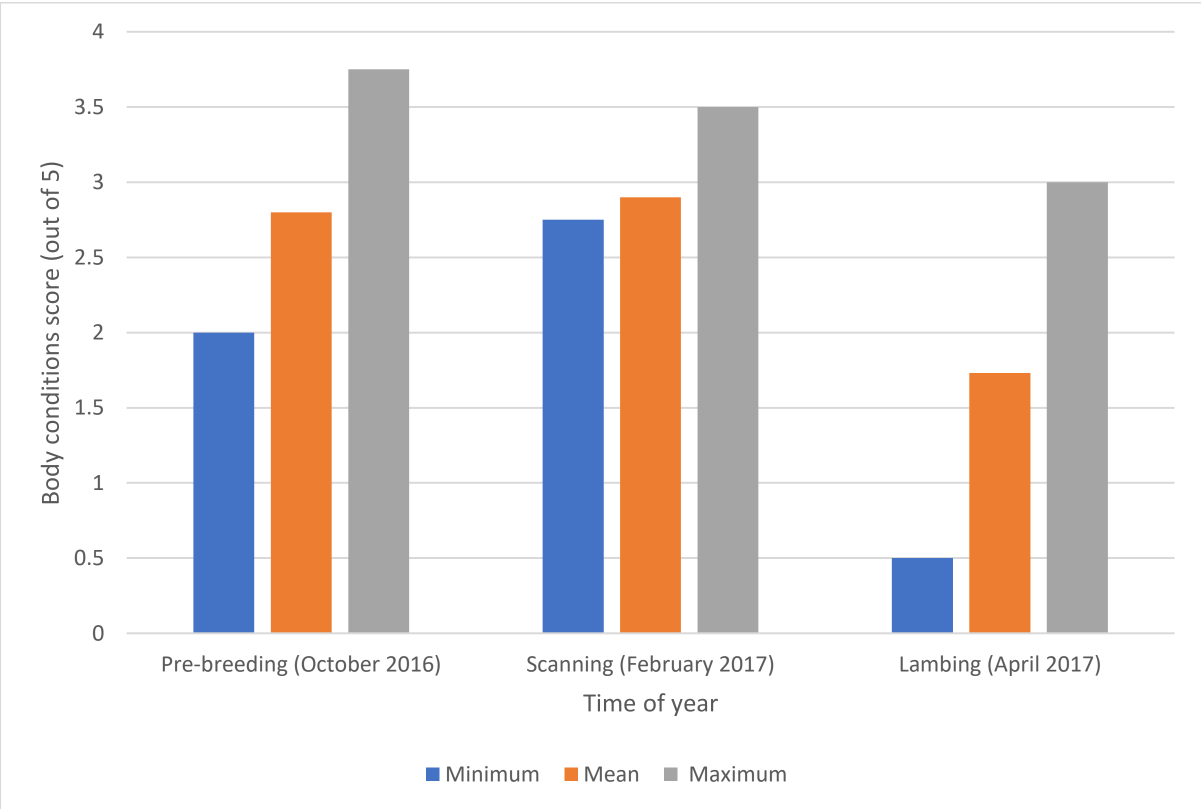

Figure 1: Ewe body condition scores recorded between 2016 and 2017, BCS was recorded for all ewes

Metabolic profile results from pregnant ewe blood samples, taken in February 2017 before BCS began to fall, gave the first indication of significant nutritional deficit (Table 2). Plasma albumin and blood urea nitrogen were low in the majority of sampled animals (Table 2, Phillips et al., 2014). Metabolisable energy (ME) appeared to be adequate for the stage of pregnancy in all but one ewe (Table 2, Russel 1985). Faecal sedimentations from ten ewes were negative for *Fasciola hepatica* eggs. At this time, the single and twin-bearing ewes were being fed grass-hay while at grass, and triplet-carrying ewes were housed with grass silage. Staged dietary interventions were implemented, with all ewes being housed in late February and fed a mixture of grass silage and whole-crop barley silage (60:40). From four weeks prior to lambing, 100g per lamb per ewe per day (i.e. 200g per day for a ewe carrying twin lambs) of protected soya (Ultra soy, NWF Agriculture) was added to the diet, this was introduced gradually over a 7 day period. Ewe BUN levels had improved when a follow-up set of blood samples were taken three weeks prior to lambing (Table 2). Lamb vigour at birth was reported to be good and lamb birthweights comparable with previous years, although this data was not available for this case report.

Table 2: Summary of metabolic blood results from pregnant ewes prior to lambing. Ten ewes with twin lambs and ten ewes with triplets were sampled at each time-point

Number of foetuses	Mean BOHB (Range)	Mean BUN (Range)	Mean albumin (Range)
	mmol/l	mmol/l	g/l
Six weeks before lambing (mid-February)			
2	0.93 (0.50 – 2.70)	1.13 (0.80 - 1.70)	29.00 (25.00 – 31.00)
3	0.53 (0.30 – 1.00)	1.15 (0.50 to 1.80)	29.73 (27.00 – 32.00)
Three weeks before lambing (mid-March)			
2	0.54 (0.38 – 1.17)	2.52 (1.58 – 3.70)	28.48 (25.10 – 33.70)
3	0.42 (0.31 – 0.56)	2.53 (1.65 – 3.53)	30.74 (26.90 – 32.50)

Target	<1.1	>1.70	>30.0

BOHB = β-hydroxybutyrate

BUN = Blood Urea Nitrogen

The reference ranges provided in Table 2 are a guide provided by the laboratory. However, plasma albumin levels are known to decrease in the final three weeks of pregnancy, therefore the results from ewes sampled in mid-March would be acceptable for the stage of pregnancy (Sykes and Thompson 1978).

Investigations

Post mortem examinations (PME) were undertaken at one of the Scottish Rural College disease investigation centres on the four lambs that presented with weakness and unresponsiveness in the first week of lambing. These revealed severe neonatal infection and tissue cultures yielded *E. coli* (Table 3). Additional PME were carried out at the practice on 11 lambs. Eight lambs had omphalophlebitis, four had septic polyarthritis, and three had rib fractures or bruising over the ribs and neck. Brown fat was present in all except one lamb. Therefore neonatal infections appeared to remain a significant contributing factor in lamb losses.

Table 3: Lamb post mortem, tissue culture and additional testing results

Date	Age (days)	Weight (kg)	ZST	Diagnosis or gross PME findings
Units	Days	kg	Turbidity units	
03/04/2017	5	5.71	4	*E.coli* septicaemia and meningitis
03/04/2017	4	5	5	Enteric colibacillosis (presumed).
03/04/2017	4	3	3	Systemic colibacillosis - meningitis and opthalmitis
04/04/2017	4	5.21	6	*E.coli* septicaemia and meningitis
20/04/2017	9	6.36	N/A	Hepatic necrobacillosis and secondary peritonitis. Polyarthritis (Sterile on culture)
21/04/2017	10-14	4.47	N/A	Septic polyarthritis. Possible enteritis.
26/04/2017		2.8	N/A	Omphalophlebitis, bruised ribs, good nutritional status
26/04/2017		9		Omphalophlebitis and septic arthritis in 3 joints, good nutritional status
26/04/2017		3.3		Omphalophlebitis, bruised ribs, oedema over neck, good nutritional status
26/04/2017		3.4		Bruising of inguinal region and thorax, straw-coloured fluid in pericardial sac, milk in abomasum (suspect fed shortly before death)
26/04/2017		3.2		Omphalophlebitis and spreading along falciform ligament. Good nutritional status
26/04/2017		4.5		Septic arthritis in left and right carpi

26/04/2017	3.3	Omphalophlebitis and spreading along falciform ligament and urachus. Septic arthritis of left elbow. Bruised ribs. Moderate/poor nutritional status
26/04/2017	5	Blood clot in abdomen
26/04/2017	6.4	Omphalophlebitis and spreading along falciform ligament. Septic arthritis of multiple joints. Good nutritional status
26/04/2017	4.2	Omphalophlebitis, spreading especially along urachus. Poor nutritional status
26/04/2017	2.5	Omphalophlebitis
Target	In lambs and kids ZST units:	> 14 = adequate colostrum absorption 5 -14 = relative FPT< 5 = absolute FPT

Following the diagnosis of neonatal infections, the on-farm investigation involved five main areas: lambing environment hygiene, navel treatment, elastrator application, colostrum management and colostrum quality (including ewe nutrition).

On this farm, lambing shed and lambing pen hygiene was good, with ewes housed in straw bedded pens until parturition. Clean straw was liberally added to the pens daily. The ewes were grouped according to predicted litter size to aid management. After parturition each ewe and her lamb(s) were moved to small 'mothering pens' for 24 to 48 hours, these had bedding removed and replaced between occupants and at all visits pens looked clean (Figure 1). The lambs were moved to large group straw bedded indoor 'nursery' pens (Figure 2), for a further one to two days before being turned out to grass.

Navel dip (10% iodine) was applied to the lambs' navels using a dipping cup, this was done while the ewe and lambs were in the mothering pens after the ewe had licked the lambs. Clean tail and castration elastrator rings were applied when lambs were 12 to 24 hours old, using clean equipment and clean hands. The lambs were given an oral probiotic supplement ('Lamb Response', Provita Animal Health) when they were moved to the mothering pens.

Staff checked that lambs had suckled within the first few hours of life. Lambs that had not suckled were given colostrum milked from the ewe, if she had enough, or powdered colostrum (Ovicol, Farmsense) by stomach tube. They were checked again within six hours. Laboratory testing was used to determine the adequacy of colostrum management and quality (Tables 4 and 5). Five of the eight lambs sampled (63%) had evidence of FPT through zinc sulphate turbidity (ZST) and total protein (TP) testing, despite the majority appearing to have consumed adequate volumes of colostrum according to the GGT results. All lambs subjected to PME at less than seven days old had evidence of FPT (Table 3).

Table 4: Blood sample results for neonatal lambs, 6th April 2017

Parameter	Age of lamb	Litter size	Ewe BCS	TP (in-house refractometer)	GGT	ZST (>14)
Units	Days		Graded out of 5	g/dL	iu/l	Turbidity units
	2	Twin	2			15
	2	Twin	2	6.2		16
	2	Twin	2			2
	2	Twin	2	4.3	190	2
	2	Twin	1.75	3.9	392	6
	2	Twin	1.75	4.2	378	5
	2	Twin	2	4.2	482	6

2	Twin	2	5.6	1130	15
Targets		2.5 – 3.0	>5.5	>= 200	> 14 = adequate colostrum absorption 5 -14 = relative FPT 5 = absolute FPT

Table 5: Body condition and colostrum quality in freshly lambed ewes

Date	Litter size	BCS ewe	Colostrum Brix	Time since lambed
Units		Graded out of 5	%	Hours
06/04/2017	2		>30	2
06/04/2017	2	1.75	27.5	3.5
06/04/2017	2	2	17	8
06/04/2017	2	1.75	28	2
06/04/2017	2	2.25	>30	1
06/04/2017	1	2.5	17	7
06/04/2017	1	2	27	8
12/04/2017	2	1.75	>30	5
12/04/2017	3	1.5	>30	1
12/04/2017	2	1.5	>30	5
12/04/2017	2	1.5	24	2
12/04/2017	2	1.75	>30	1
12/04/2017	2	1.5	29.5	1
12/04/2017	1	2.5	23	9
12/04/2017	2	2	>30	0

12/04/2017	2	2	34	0
25/04/2017	2	2.75	>30	2.5
25/04/2017	1	1.5	>30	4.5
25/04/2017	2	2		>10
25/04/2017	2	1.5		>10
25/04/2017	2	2		>10
25/04/2017	2	2.5		>10
25/04/2017	1	1.5		>10
25/04/2017	1	1.75		>10

The body condition of nearly all ewes examined was below or well below target (2.5 to 3 out of 5, Russel 1985). ME and metabolisable protein (MP) were calculated for the post-housing diets (fed from late February onwards), using standard grass silage and wholecrop values. For this diet, fed subsequent to the metabolic profiles, there was an excess of MP but a deficit of ME in the last 3 weeks of pregnancy (Table 6, Wright 2016).

Table 6: Metabolisable energy (ME) and metabolisable protein (MP) of the pre-lambing ewe diet for a 70kg ewe, assuming dry matter intakes of 2% of ewe bodyweight. Recommendations from AHDB (Wright 2016)

Litter size	Weeks pre-lambing	ME		MP	
Units		MJ		g	
		Actual	Recommended	Actual	Recommended
2	3	15.4	15.3	262.7	112
	1	15.4	18.3	262.7	126
3	3	15.6	16.7	290.5	119

1	15.6	20.3	290.5	136

Post-natal ewe nutrition consisted of grazed grass and wholecrop silage, plus 500g ewe compound feed with 18% crude protein, giving an ME of 16MJ and MP of 221g per head per day.

Differential diagnosis

In this case, the majority of the ewes on the farm had low BCS (Table 5), therefore the main focus of the investigation was on nutritional deficits and chronic infestation with *Fasciola hepatica*. No evidence of adult *F. hepatica* was found, whereas grass supply had been inadequate prior to housing, with the hay provision not adequately compensating for this. The post-housing diet also had an energy deficit in late pregnancy.

PME findings from lambs in this case revealed systemic infection and blood samples revealed FPT. Also, affected lambs had appeared normal at birth. Therefore neonatal, rather than pre-natal, infection was considered most likely. Indoor lambing always poses a risk for neonatal infection, however lambing-time hygiene was good on this farm.

FPT can be due to lack of colostrum, poor colostrum quality, late ingestion of colostrum or poor neonatal absorption of antibodies. Labour provision during lambing was good in this flock, therefore late ingestion of colostrum in a high proportion of lambs was unlikely. Whereas, low ewe BCS, a history of poor ewe nutrition and the pre-lambing metabolic blood results suggested that inadequacies of pregnant ewe nutrition led to poor colostrogenesis. Excess maternal iodine supplementation may interfere with lamb absorption of colostral immunity (Boland et al. 2005), however ewes had not been given supplementary iodine in this case and these problems had not been noted in the region in previous years. Neonatal infection due to FPT, secondary to poor colostrum production by malnourished ewes was the presumptive diagnosis.

Treatment

After the initial PME and farm visit, preventative measures were implemented to protect subsequent new born lambs. Each new born lamb received 0.5ml amoxillicin (150mg/ml Betamox LA, Norbrook) by intramuscular injection, to reduce the establishment of infections in the first two days of life. Navel treatment was administered as soon after birth as possible instead of waiting until the lamb was dry, in order to prevent establishment of infection before treatment occurred. This was repeated two hours later in case the ewe had licked off the iodine. Navel dipping cups were washed daily with warm water and soap to ensure no organic matter built up in them acted as a nidus for infection. Staff were advised to check ewe udders for milk immediately after parturition and check whether lambs had suckled within two hours of birth. The probiotic supplement was not to be given before lambs had colostrum, to reduce the risk of introducing bacteria before acidification of the abomasum or the arrival of colostral antibodies (Yilmaz and Kasikci 2013).

Replacement colostrum was recommended for lambs from ewes under BCS 2 (on a scale of 0 to 5), triplet litters, dams without much milk and weak lambs. Surplus ewe colostrum from ewes with single lambs was not readily available, so colostrum was used from beef cows on the same farm. The colostrum from three cows was to be pooled, split into 150ml portions and frozen ready for use. However this colostrum was not available until the last week of lambing. Commercially produced powdered colostrum was used in the interim; as for cattle, this is likely to be a poor substitute for ewe colostrum (Corke 2012). Vaccination of lambs for *Clostridial* diseases at three weeks of age was advised due to the FPT.

Measures were also taken to rectify the body condition of the ewes. To improve milk production for the present lamb crop and restore the ewes for breeding the following season. Ewes in BCS 1.5 (out of 5) or less reared a maximum of one lamb, additional lambs were reared artificially. For the first six weeks after lambing good grazing was prioritised for the ewes, they were also fed 500g of compound feed daily for the first two weeks of lactation, then the compound feeding was reduced as grass growth increased. All of the lambs were fed compound feed through a creep system from three weeks of age and weaned at 12 to 16 weeks of age.

Ewe nutrition for subsequent lambings was discussed with the farm manager, however due to unrelated circumstances the flock was disbanded before the next breeding season.

Discussion

It seemed that in this case ewe undernutrition and low BCS at lambing may have contributed significantly to FPT, lamb morbidity and mortality. The lambs were considered to have good vigour after birth and acceptable birthweights, however Dwyer et al. (2003) found that ewes subjected to moderate undernutrition expressed poorer maternal behaviour, reducing the ewe-lamb bond. Also, small reductions in birthweight of lambs (3.31 verses 3.00) significantly affected lamb suckling. A reduction in lamb birthweights of this scale might go unnoticed, but could still lead to reduced suckling behaviour and therefore impact colostrum intake.

It can be difficult to fully meet the ME needs of ewes carrying multiple lambs in late pregnancy without the use of body reserves, which requires an absolute minimum BCS at lambing of 2 (Russel 1985), many of the ewes assessed in this case had a BCS below this. Also, synchrony in the supply of ME, particularly fermentable metabolizable energy (FME), and MP is required to allow ruminants to utilise dietary protein (Sinclair et al. 1993). Complete dietary analysis, to allow full assessment of FME and Effective Rumen Degradable Protein, was not available in this case, therefore the calculations used here have reduced accuracy. However they suggest some macronutrient insufficiencies, therefore lamb birthweight (Wallace 1948), udder development and colostrogenesis (Mellor 1990) would be expected to have suffered.

The quality of colostrum from ewes is difficult to ascertain without significant expense. Brix refractometer readings are cheap and easy to obtain, but ovine colostrum Brix readings have not been correlated with gammaimmunoglobulin levels in lambs, therefore these readings were difficult to interpret (Torres-Rovira et al. 2017). Therefore assessment for FPT in lambs was done using the zinc sulphate turbidity (ZST) test (Hogan et al. 2016) and plasma total protein (TP, Weaver et al. 2000). These tests are used in practice as an indirect measure of serum immunoglobulin levels in lambs as well as calves. Colostrum intake can also be indicated by γ-Glutamyl Transferase (GGT) levels in lamb plasma, as GGT levels are high in colostrum and are readily absorbed by neonatal lambs (Maden et al. 2003; Britti et al. 2005). Low ZST but adequate GGT results in lambs in this case indicated that either the colostrum quantity, quality or time of intake were inadequate (Yilmaz and Kasikci 2013). Neonatal deaths often increase towards the end of lambing (Casellas et al. 2007), although one study has shown an association between early lambing season births and reduced lamb serum immunoglobulin (Christley et al. 2003), as was seen in this case. Nevertheless, ongoing cases of early onset septic polyarthritis suggested continued FPT. A link between FPT and septic arthritis has been seen in foals (Koterba et al. 1984) and could reasonably be expected in lambs also.

The risk factors associated with neonatal lamb mortality are multifactorial (Dwyer et al. 2016) and determining the contributing factors on any one farm can be difficult, but is vital in order to implement preventative measures within the same and future lambing periods. Diagnosis of major causes of neonatal mortality is also necessary to justify the use of prophylactic antibiotics or provide proof for the client that these are not necessary. When unselective prophylactic antibiosis is used it is difficult to ascertain its impact, because there is no untreated control group. In this case, four lambs died of neonatal infection within a two-day period before the implementation of prophylactic antibiotic treatment. In the eight days after implementation six lambs died or were put down, due to suspected (but not confirmed) neonatal infection. More chronic sequelae of neonatal infection were seen after this, such as septic polyarthritis and endocarditis. The antibiotics may have reduced the incidence of neonatal infections or not, or may have delayed the effects in some lambs. However, it is difficult to justify the continuation of blanket prophylactic use of antibiotics in the face of reports of antibiotic resistance related-issues (Bush et al. 2011). Other control measures discussed here, such as good colostrum provision and management, hygiene and navel treatment are recommended and preferable (Lovatt et al., 2019). This case demonstrates that good management and nutrition from pregnancy through to weaning must be made a priority to safeguard on-farm productivity and animal welfare, particularly on sheep breeding enterprises where neonatal mortality is a concern.

Figure 1: Mothering pen prepared for new occupants

Figure 2: Ewe and 48 hour old lambs in a ‘nursery pen’

Ethical approval

All procedures undertaken during this case were part of a normal clinical investigation and are therefore covered by the Veterinary Surgeons Act 1966.

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