Could beta hydroxyl butyrate levels in dead lambs be used as a diagnostic tool for assessing ewe nutrition? A Neil Bruère Scholarship funded project

G Dodunski, T Cook
Totally Vets Ltd

Abstract
A field study was undertaken to attempt to determine a relationship between maternal and fetal serum Beta Hydroxy Butyrate (BOHB) levels in sheep. No relationship was found, with lambs displaying uniformly low to very low serum BOHB, whilst ewe levels ranged from 0.1mmol/L to 1.76mmol/L.

A test that could be applied to lambs at post mortem examination to determine the adequacy of the feeding level of the dam could be a very useful tool to veterinarians advising sheep farmers.

Aim
To determine if there is a relationship between the serum BOHB level of ewes and the serum BOHB level of their lambs at birth.

Background
A key driver of profitability of ewe flocks is the number of lambs weaned.

On many farms ewe fertility has improved to an optimal point, and while there is still much opportunity for improved lamb growth on many farms, it is the survival of multiple born lambs that is the key ‘crunch’ point for many ewe flocks.

This limitation has been present for over a decade and while advisory and extension services have in recent years increased the emphasis on the importance of optimal pre-lamb ewe body condition and feed levels1 it can be difficult to demonstrate to individual farmers that there is scope for this to be better managed on their own properties.

Post mortem examination of dead lambs has been a traditional tool used by sheep and beef veterinarians to help farmers pinpoint their key causes of lamb loss in the peripartum period.

Currently a large proportion of dead lambs available for post-mortem are simply classified under the ‘starvation/exposure/mismothering’ (SEM) category, which is fairly unhelpful to farmers wanting to make management changes to address lamb losses, and not specific enough for a veterinarian who may have had insufficient contact with the client, or experience, to assess ewe body condition, feed covers, appropriateness of winter management, set stocking date, lambing date etc.

It is highly likely that a large proportion of SEM lambs have been slow to stand and suckle, resulting in them being mismothered.

In addition, a significant number of lambs are simply dead at birth. While some of these are clearly due to dystocia, many show no obvious signs of a cause.

Under many New Zealand farm management systems, multiple bearing ewes are underfed in the immediate weeks pre-lamb. When feed budgets are performed for many breeding ewe systems, there is a mismatch between pasture supply (growth rate and standing feed) and the requirement of the multiple-lambing ewes immediately pre-lamb.

As little as a 10% reduction in energy intake below requirement in this period has been shown to cause major metabolic changes in ewes, including raised BOHB levels (Charismiadou et al. 2000).

Increased BOHB concentrations present in fetal and perinatal lamb blood can cause significant reductions in foetal PaO2 and increased lactate levels (Miodovnik et al. 1982).

Fetal hypoxaemia has been shown to inhibit heat production after birth. In a large-scale UK study of the biochemical parameters of ewes and their new-born lambs, Barlow et al. (1987) found that 35% of lambs which died (and from which blood was taken at birth) had changes in blood parameters consistent with intrapartum hypoxaemia in the absence of obvious dystocia.

Studies show that the speed with which a new born lamb stands and suckles after birth strongly influences its long term survival rate (Dwyer 2003) Depressant effects within the lamb secondary to raised maternal BOHB (without the ewe being clinically ketotic) have been postulated to be a major contributor to the SEM complex on New Zealand farms2.

Evidence for this has been provided during the course of the Poukawa Elite Flock Project (Muir and Thomsen 2009), where it was demonstrated that within a range of BOHB values below the cut-off for clinical ketosis, that there were negative effects on lamb survival from the dam having a raised BOHB level.

A finding of particular interest was that ewes that produced one or more lambs that were dead at birth, had significantly higher BOHB levels than their cohorts.

2 T Cook Pers. Comm.
A means of measuring the degree of BOH-induced depression on new-born lambs would present a powerful new tool for those advising farmers on ewe flock management, where currently, messages around improved feeding of high performing ewes pre-lamb are receiving only limited uptake by farmers.

This is in line with the Red Meat Sector Strategy (McLeod 2011), which holds that a large percentage of existing unrealised revenue from the sector sits behind the farm gate and can be unlocked with more extensive adoption of known best practice.

There has been no New Zealand study that has quantitatively linked the BOHB level of the late pregnant ewe with any biochemical parameters in the newborn lamb/s.

If such a link could be established in live lambs; there could be the potential for the measurement of metabolites in dead lambs.

The ultimate end-goal would be a reference range that assigns dead lambs as having been born to an adequately fed or underfed ewe, in the absence of visible post-mortem changes.

Thus the current study is a pilot that will hopefully be used as a platform for further work.

**Materials and methods**

On four lowland Manawatu sheep farms, up to 10 twin bearing ewes per farm, and their new-born lambs were blood sampled for serum Beta Hydroxybutyrate (BOHB) levels.

<table>
<thead>
<tr>
<th>Farm</th>
<th>No. ewes sampled</th>
<th>No. lambs sampled</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
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<td>4</td>
<td>Poor facilities; unable to catch both twins</td>
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<tr>
<td>2</td>
<td>6</td>
<td>10</td>
<td>Romney stud</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>15</td>
<td>Stud embryo transfer Dorpers, history of Milk fever and sleepy sickness approx. three weeks prior to lambing</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>2</td>
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<td>Total</td>
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On each farm it had been intended to collect samples from 10 ewes and their lambs; however under the field conditions that the study was run, we were unable to collect the desired number of samples.

Under the protocol, lambs were to be caught and sampled within less than 12 hours of birth. In two instances, on Farm 3, a ewe and her lambs were sampled outside this window (17 hours and 21 hours in each case). In six instances, this information was not available but lambs were definitely less than 24 hours old.

Other information recorded included:
- Liveweight of lamb/s
- Whether or not lambs had fed
- Body condition score of the ewe
- Length of pasture being grazed
- Ewe age
- Ewe breed
Could Beta hydroxyl butyrate levels in dead lambs be used as a diagnostic tool for assessing ewe nutrition?

- Any history that may have been pertinent; for example on Farm 3 a number of ewes had been previously treated for milk fever and sleepy sickness.

The first four parameters above were assessed by the attending veterinarian, the last three provided by the farmer.

The serum BOHB levels of the ewes and their new-born lambs were compared to observe whether any relationship existed.

Results

Table 2. Raw data.

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<thead>
<tr>
<th>ID</th>
<th>Lamb1 LW (kg)</th>
<th>Lamb2 LW (kg)</th>
<th>Hours from birth</th>
<th>Lamb 1 Fed Y/N</th>
<th>Lamb 2 Fed Y/N</th>
<th>Ewe age (Years)</th>
<th>Ewe BCS</th>
<th>Grass level (cm)</th>
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<td>Romney</td>
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<td>3.5</td>
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<td>4</td>
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<td>2</td>
<td>3.5</td>
<td>Comp</td>
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<td></td>
<td>0.80</td>
<td>0.10 0.10</td>
<td></td>
</tr>
</tbody>
</table>

6.3.4 Proceedings of the Society of Sheep & Beef Cattle Veterinarians of the NZVA Annual Conference, 2014
Relationship between ewe and lamb BOHB levels

There appeared to be no relationship between the BOHB level of the pregnant ewe, and that of her lamb/s. The BOHB levels in the lambs were consistently low (in all cases lamb BOHB was less than 0.3mmol/L, and all but two of these were 0.2mmol/L or less).

BOHB levels in the ewes ranged from 0.1 to 1.76mmol/L (clinical reference range 0.1-1.5mmol/L), though when the one high value of 1.76mmol/L is excluded, all other ewe BOHB values were 1mmol/L or less and therefore not ‘clinically’ ketotic.

Note that all ewes for which the information was available were at or above industry standard for pre-lamb body condition score (BCS), and the pasture they were grazing was similarly at or above industry guidelines for lambing feed (Geenty 1997). Most lambs fell within a birthweight range that was optimal for survival (3.5-5.5kg) (Geenty 1997).

Effect of hours since parturition

Within the range of hours from parturition that this sampling was undertaken, there appeared to be no effect of time after parturition on either ewe or lamb BOHB levels.
Could Beta hydroxyl butyrate levels in dead lambs be used as a diagnostic tool for assessing ewe nutrition?

In all cases where both lambs in a set of twins were sampled there was either no (n=6) or minimal (n=3) difference between the two lambs for BOHB.

### Differences between farms

<table>
<thead>
<tr>
<th>Farm</th>
<th>Ewes BOH</th>
<th>Lamb/s BOH</th>
<th>Difference</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>0.92</td>
<td>0.21</td>
<td>0.71</td>
</tr>
<tr>
<td>2</td>
<td>0.33</td>
<td>0.08</td>
<td>0.25</td>
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<td>3</td>
<td>0.65</td>
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<tr>
<td>4</td>
<td>0.8</td>
<td>0.1</td>
<td>0.7</td>
</tr>
</tbody>
</table>

There was some difference in the mean ewe BOH level between farms; of a magnitude that may be attributed clinical significance by some practitioners. However given the very low numbers of individual ewes contributing to some of these means, it is probably unwise to attribute too much significance to these differences.

### Ewes with history of previous metabolic disease

The ewes had a history of having been treated for ketosis/milk fever approximately two weeks previously.

The BOHB levels in these ewes were 0.5, 0.5 and 0.8mmol/L. The average of all the ewes sampled was 0.62mmol/L.

One ewe gave birth to a lamb with obvious goitre; this ewe had a BOHB level of 0.1mmol/L.

The lambs from all these ewes had BOHB levels of 0.2mmol/L or less.

### Discussion

While it seems likely that there is a 'subclinical’ range of ewe BOHB values that are associated with reduced lamb survival, it would appear that BOHB is not the appropriate parameter to measure in new-born lambs.

Although most of the ewes in this study returned serum BOHB values within a low to moderate range, the BOHB of the lambs was uniformly low, including those of the individual ewes with serum values greater than 0.8mmol/L.

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3 T Cook Pers. Comm.
All of the lambs sampled in this study had drunk colostrum prior to being blood sampled and it is conceivable that this influenced the results, although other workers have measured BOHB levels from lambs immediately after birth and been similarly unable to detect variation in serum ketones (Snook and Godden 1938).

Snook and Godden (1938) demonstrated that lambs from both healthy and ketotic ewes had virtually undetectable levels of serum ketones; whereas the lambs from normal ewes showed a greater and more prolonged rise in blood glucose after birth (postulated to arise from mobilisation of liver glycogen on exposure to cold temperatures) than the lambs from the ketotic ewes.

Other workers have measured plasma glucose, fructose and lactate in new-born lambs when investigating various aspects of ewe and lamb performance (Kronfeld 1957, Kerslake et al. 2010).

Apart from the 1938 reference above, we have been unable to find any work that quantitatively links ewe BOHB to any of these metabolites. This could be an area for further work.

Measurement of BOHB levels in periparturient ewes in lamb survival investigations on commercial farms in New Zealand is problematic because of the spread in possible lambing dates, and because of practical issues around access to ewes at this time.

A test applied to dead lambs that assessed dam feeding level would be a most useful tool in providing farmers with better information on their flock management and performance. For some it may be the extra spur they need to better apply known best practice to their own ewe flock management.

It could also be a great ‘foot in the door’ for veterinarians providing advisory services to sheep and beef clients, and create another contact point for veterinarians with their sheep farmer clients.

**Acknowledgements**

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Snook LC, Godden W. The sugar and total ketone content of the blood of ewes and of their new-born lambs. *Biochem J* 32 (11), 2037–2039, 1938

Kronfeld DS. A comparison of normal concentrations of reducing sugar, volatile fatty acids, and ketone bodies in the blood of lambs, pregnant ewes, and non-pregnant adult ewes. *Australian Journal of Agricultural Research* 8, 202–208, 1957