Supporting your success

Lamb survival is improved by reducing mob size and stocking rate at lambing: Part 1

This is the first of a two part report investigating the impact of mob size and stocking rate on lamb survival. Part two will be published in the March 2017 edition of the Ovine Observer.

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Introduction

Improving the survival of lambs is a priority for the Australian sheep industry as approximately 30% of all lambs born die prior to weaning.

Importantly over 80% of these deaths occur within the first three days of life. In order to reduce these deaths, the complex factors influencing lamb mortality must be investigated.

There are indications that two management factors, mob size and stocking rate, have a realtionship with lamb survival, although they are poorly understood in a commercial setting.

Research in small 0.5ha paddocks, which don’t reflect grazing conditions on commercial properties, showed:

- The survival of twin-born lambs is 20% higher in ewes lambing at 16 ewes/ha compared to ewes lambing at 30 ewes/ha in sheltered paddocks.
- For each extra lambed ewe per hectare, 2% more ewes became permanently separated from one or more of their lambs.
Therefore, in order to see if these relationships persisted in a commercial setting the study reported here tested the hypothesis that increasing the mob size or stocking rate of lambing ewes on commercial properties will reduce the survival of their lambs.

Methods

A total of 66 sheep producers which ran separate mobs for single and twin bearing ewes after pregnancy scanning, were surveyed in 2014 through the BESTWOOL / BESTLAMB program in Victoria. Data was collected for a total of 300 individual mobs of single- and twin-bearing ewes that lambed between 2007 and 2013. Ewe and ram breeds included both Merinos and maternal breeds.

Information on mob size, stocking rate and lamb survival was collected. Lamb survival to marking was calculated based on the total number of foetuses identified at pregnancy scanning and the number of lambs marked within each paddock. All statistical analyses were performed using GENSTAT (VSN International 2012). The survival of lambs within paddocks was assessed using linear mixed models. For all analyses, terms were only included if they were statistically significant (P≤0.05).

Results

1. Twin and single lamb survival
   - Single born lambs had a greater survival than twin lambs for both Merino and Maternal ewes (P<0.001) (Table 1).
   - Maternal ewes also had a greater lamb survival than Merino ewes for both singles and twins (P<0.001).

2. Ewe age and lamb survival
   - Lambs born to more mature ewes aged 2 years or older had increased survival rates than those born to inexperienced, younger ewes that were a year old (P<0.001).

3. Ewe body condition and lamb survival
   - Ewe body condition score at lambing impacted on lamb survival, with 10% more lambs surviving for every 0.5 increase in condition score (P>0.001).
   - Furthermore, for each 0.5 condition score gain between lambing and marking, lamb survival increased by 5.6% ± 2.0% (P<0.01).

4. Mob size and lamb survival
   - The survival of single- and twin-born lambs decreased by 1.4% and 3.5% for each additional 100 ewes in the mob (Figure 1; P<0.01).
   - Lamb survival also decreased by 0.7% for each additional ewe per hectare (P<0.01).

<table>
<thead>
<tr>
<th></th>
<th>Single</th>
<th>Twin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merino</td>
<td>80.9</td>
<td>59.5</td>
</tr>
<tr>
<td>Maternal</td>
<td>87.1</td>
<td>73.8</td>
</tr>
</tbody>
</table>
The effect (± 95% confidence intervals) of increasing the mob size of single-bearing ewes (black) and twin-bearing ewes (grey) at a stocking rate of 8 ewes/ha on lamb survival in experiment one. Lambs were born to ewes of Merino and maternal breeds.

Points to note:
1. Lamb survival decreased with increasing mob size
2. The decrease in lamb survival was more noticeable in twin lambs

Take home messages
Increasing the number of ewes in lambing mobs may amplify the risk of disturbances from other lambing ewes and therefore the risk of cross-fostering, ewe-lamb separation and lamb mortality.

The greater effect of mob size on twin lamb survival is likely to be a result of an increased number of lambs born per day, further compounded by the increased difficulty for ewes to mother multiple lambs.

Increasing the number of lambs born per day may also compromise the time the ewe and lamb spend at the birth site, and increase the incidences of cross-fostering and ewe-lamb separation. Twinning has been shown to decrease the ability of Merino ewes to bond with their young and delay maternal recognition in lambs.

The average mob size of twin-bearing ewes in this study was 180. We have calculated that:
- Reducing the mob size from 180 to 100 would increase lamb survival by 2.8% for twin-bearing ewes and therefore increase marking rate by 5.6%.
- This is equivalent to the increase in lamb survival expected from increasing the body condition score of ewes from 3.0 to 3.3 at lambing based on the effect of condition score at lambing on lamb survival in this study, and previous research.

Overall this study indicates that reducing the mob sizes and stocking rates of lambing ewes will improve lamb survival, particularly for twins.

Work is currently underway to quantify the effects of mob size and stocking rate on the survival of twin-born lambs on commercial farms across all of Australia.

Acknowledgements
BESTWOOL/BESTLAMB is supported by the Department of Primary Industries Victoria and Australian Wool Innovation Ltd. The producers who participated in the program are sincerely thanked for their contributions.
Comparative analysis of gross margins for grain and sheep enterprises in the central and high rain fall regions of the Western Australia (WA) wheat belt

Ashley Herbert, Agrarian Management

This is the second and third parts of a three part report. Part one was published in the October 2016 edition of the Ovine Observer.

Part 2: Projected Gross Margins for 2016

A series of gross margins have been calculated for each zone based on expected costs, production and prices to be received for the 2016 season. Details of costs included are outlined in Table 1.

By all accounts, 2016 has been an exceptional season across most, if not all of the Western Australian agricultural regions. The season has been characterised by good early rain and consistent growing season rainfall. Consequently, crop yield and sheep production expectations are high. While sheep and wool prices have remained strong, cereal grain prices have declined significantly through the season.

Cropping costs are expected to be above average mainly due to significant amounts of additional herbicides applied. Conversely, the early start to the season has greatly reduced the supplementary feed costs of the sheep enterprise.

In view of the comments in part one, these projections should be viewed as indicative only. They are in no way intended to be a definitive statement on the profitability of each enterprise.

Cereal Sheep Zone

These calculations are based as much as possible on actual farm data. The yield expectations are the highest annual averages achieved in the past for the dataset.

Table 1 Projected gross margins for the Central Sheep Zone based on estimated price and production for 2016

<table>
<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>Barley</th>
<th>Canola</th>
<th>Lupins</th>
<th>Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (T/ha)</td>
<td>2.5</td>
<td>2.8</td>
<td>1.3</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Price ($/T FIS)</td>
<td>$250</td>
<td>$200</td>
<td>$550</td>
<td>$350</td>
<td></td>
</tr>
<tr>
<td>Costs ($/ha)</td>
<td>$270</td>
<td>$274</td>
<td>$302</td>
<td>$260</td>
<td></td>
</tr>
<tr>
<td>Gross Margin ($/ha)</td>
<td>$235</td>
<td>$167</td>
<td>$299</td>
<td>$195</td>
<td>$180</td>
</tr>
</tbody>
</table>

Figure 1 Projected gross margins for the Central Sheep Zone based on estimated price and production for 2016
Despite the low grain price outlook for the coming harvest, the projected gross margin is significantly buoyed by the above average yields expected. Provided the yield estimates are achieved, the crop enterprise is quite likely to achieve at least an average gross margin.

The gross margin for sheep of $180/ha is significantly above the medium term average of $102/ha which underlines the current strength of the sheep and wool markets.

**High Rainfall Zone**

These calculations are based, as much as possible, on actual farm data. The yield expectations are the highest annual averages achieved in the past for the dataset.

Table 2 Projected gross margins for the High Rainfall Zone based on estimated price and production for 2016

<table>
<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>Barley</th>
<th>Canola</th>
<th>Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (T/ha)</td>
<td>3.7</td>
<td>3.7</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Price ($/T FIS)</td>
<td>$250</td>
<td>$200</td>
<td>$550</td>
<td></td>
</tr>
<tr>
<td>Costs ($/ha)</td>
<td>$364</td>
<td>$367</td>
<td>$373</td>
<td></td>
</tr>
<tr>
<td>Gross Margin ($/ha)</td>
<td>$407</td>
<td>$289</td>
<td>$528</td>
<td></td>
</tr>
<tr>
<td>Stocking rate (dse/ha)</td>
<td></td>
<td></td>
<td></td>
<td>$10.5</td>
</tr>
<tr>
<td>Wool Price ($/kg grsy NIB)</td>
<td></td>
<td></td>
<td></td>
<td>$8.80</td>
</tr>
<tr>
<td>Wool Cut (Kg/hd)</td>
<td></td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Shippers ($/hd)</td>
<td></td>
<td></td>
<td></td>
<td>$110</td>
</tr>
<tr>
<td>CFA Ewe ($/hd)</td>
<td></td>
<td></td>
<td></td>
<td>$65</td>
</tr>
<tr>
<td>Gross Margin ($/ha)</td>
<td></td>
<td></td>
<td></td>
<td>$438($42/dse)</td>
</tr>
</tbody>
</table>

Canola continues to be the most profitable enterprise owing to the combination of high yields and strong pricing.

The high yield expectations are likely to deliver an above average profit for the crop enterprise despite the lower pricing.

Figure 2 Projected gross margins for the HRZ based on estimated price and production for 2016

It is worth making the point that while the sheep margin is similar to the wheat margin; it is at a high figure by historical standards. Given the prices of cereals have declined significantly, the overall profitability is held up by the exceptional seasonal conditions.

**Part 3: Sheep enterprise comparison**

In this section, the profitability of four sheep enterprises, are compared as detailed below. The base assumptions are taken from the High Rainfall Zone.
<table>
<thead>
<tr>
<th>Enterprise</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Merino</td>
<td>Self-replacing merino flock. 4 age groups of joined ewes 1.5 – 4.5yo. Selling wethers as shippers off shears at 12 -18mths.</td>
</tr>
<tr>
<td>2. Prime lamb</td>
<td>100% merino ewe flock joined to terminal sire. 5 age groups of joined ewes 1.5 – 5.5yo. Replacement ewes purchased at 1.5yo. Lamb sale value equal to shipper price.</td>
</tr>
<tr>
<td>3. Merino 30% XB</td>
<td>Self-replacing merino flock with 30% ewes joined to a terminal sire. Proportional mix of flocks 1 &amp; 2. Replacement ewes sourced from retained ewe hoggets.</td>
</tr>
<tr>
<td>4. Non-shearing</td>
<td>Non-specific non shearing breed. 5 age groups of joined ewes 1.5 – 5.5 yo. Replacements sourced from retained ewe hoggets. Lamb sale value equal to shipper price.</td>
</tr>
</tbody>
</table>

The analysis of Flock Four (Non-shearing) is based on broad general assumptions and is presented here only as a guide to the possible gross margin. Objective data on these types of enterprises is difficult to come by. Results presented here should be viewed in this context.

Table 3 Projected Gross Margin ($/ha) for a merino and prime lamb enterprise based on 2016 price and production assumptions for the High Rainfall Zone

<table>
<thead>
<tr>
<th></th>
<th>Merino</th>
<th>Prime Lamb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stocking rate</td>
<td>$10.5 dse/ha</td>
<td>$10.5 dse/ha</td>
</tr>
<tr>
<td>Wool income</td>
<td>$434</td>
<td>$353</td>
</tr>
<tr>
<td>Livestock Trading Profit</td>
<td>$270</td>
<td>$521</td>
</tr>
<tr>
<td>Total Income</td>
<td>$704</td>
<td>$874</td>
</tr>
<tr>
<td>Costs</td>
<td>$235</td>
<td>$246</td>
</tr>
<tr>
<td>Gross margin</td>
<td>$438</td>
<td>$594</td>
</tr>
</tbody>
</table>

On a like for like for basis, the Prime lamb enterprise is significantly more profitable than the typical merino flock ($438/ha vs $594/ha Table 6). The core assumptions being that stocking rate, lambing rate and sale price are equal.

In reality, this is not always the case. There are often a number of differences between the two enterprises that effectively reduces the difference in profitability.

In general, the prime lamb system is focused on achieving a finished lamb price based on the assumption that price drives profit. To achieve this, there are a number of adjustments made to the system to be able to sell lambs at the targeted price. All of which are quite legitimate and understandable.

The first and most significant is the time of lambing. In order to have lambs of a sufficient weight to achieve the target price, lambing needs to be relatively early (eg April/May). As a consequence, stocking rate is reduced. This is usually in the order of 20% less than a July time of lambing.

Table 4 Projected Gross Margin ($/ha) for a merino and prime lamb enterprise based on 2016 price and production assumptions for the High Rainfall Zone

<table>
<thead>
<tr>
<th></th>
<th>Merino</th>
<th>Prime Lamb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stocking rate</td>
<td>$10.5 dse/ha</td>
<td>$8.4 dse/ha</td>
</tr>
<tr>
<td>Wool income</td>
<td>$434</td>
<td>$263</td>
</tr>
<tr>
<td>Livestock Trading Profit</td>
<td>$270</td>
<td>$407</td>
</tr>
<tr>
<td>Total Income</td>
<td>$704</td>
<td>$670</td>
</tr>
<tr>
<td>Costs</td>
<td>$235</td>
<td>$198</td>
</tr>
<tr>
<td>Gross margin</td>
<td>$438</td>
<td>$472</td>
</tr>
</tbody>
</table>
In addition, the ewes tend to be kept for longer to reduce the number of replacements ewes required each year. The consequence of this is that losses are slightly higher, average wool cut is slightly lower and the fibre diameter is slightly broader leading to slightly lower fleece values.

Furthermore, costs will be higher if significant amounts of grain are fed to carryover lambs.

All in all, the net effect of these adjustments is to erode the potential difference in profitability as summarised in Table 4. The prime lamb enterprise is around 10% more profitable.

Following from this is an analysis of the two other sheep enterprises, Flocks Three and Four – Merino flock with 30% ewes joined to a terminal and a non-shearing breed.

Table 5 Projected gross margins ($/ha) for a range of sheep enterprise based on 2016 price and production assumptions for the High Rainfall Zone.

<table>
<thead>
<tr>
<th>Stocking rate (dse/ha)</th>
<th>Merino</th>
<th>Prime lamb</th>
<th>Merino 30% XB</th>
<th>Non-shearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool income</td>
<td>$434</td>
<td>$263</td>
<td>$366</td>
<td>$0</td>
</tr>
<tr>
<td>Livestock Trading Profit</td>
<td>$270</td>
<td>$407</td>
<td>$310</td>
<td>$542</td>
</tr>
<tr>
<td>Total Income</td>
<td>$704</td>
<td>$670</td>
<td>$676</td>
<td>$542</td>
</tr>
<tr>
<td>Costs</td>
<td>$235</td>
<td>$198</td>
<td>$224</td>
<td>$124</td>
</tr>
<tr>
<td>Gross margin ($/dse)</td>
<td>$438</td>
<td>$472</td>
<td>$452</td>
<td>$418</td>
</tr>
</tbody>
</table>

The results presented in Table 5 show little fundamental difference between enterprises.

A possible exception might be the non-shearing flock where a very high lambing rate is required to compensate for the absence of wool income. For the Non-Shearing enterprises to equal the profitability of more conventional sheep enterprises, lambing rates need to be close to 140% (of joined mature ewes).

The general belief is that these breeds readily achieve these high lambing rates, almost as a matter of course. While objective benchmark data isn’t widely available, this doesn’t seem to be the case. While anecdotal evidence suggests such lambing rates are certainly achieved this is only after considerable care and attention to detail has been exercised.

It is important to remember that the variation between individual farms within each enterprise group is significant. As highlighted in Figure 6 of Part one presented in the October 2016 edition of the Ovine Observer, there is a large degree of variation in profitability between farms. The variation between individuals will eclipse any fundamental difference that may exist between the livestock enterprises.

The performance of management is a far greater profit driver than the actual enterprise per se. With appropriate management, each enterprise can perform equally well.

The main conclusion is that there isn’t a demonstrably “most profitable sheep enterprise”. Profitability is highly dependent upon a wide range of variables that are equally variable between individual producers and enterprises.

This also suggests there doesn’t appear to be any real difference between the value of wool and livestock sales to significantly favour one enterprise over the other. The relative value of a particular enterprise to an individual producer is most likely to be determined by the individual’s preference, motivation and management skill.

This analysis was commissioned by the Department of Agriculture and Food, Western Australia’s Sheep Industry Business Innovation project as part of its work around understanding the barriers to increasing supply of lambs in WA.
Is carb-loading good for reproduction?

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Introduction
Breeding from ewe lambs increases reproductive efficiency and speeds up genetic improvement programs by decreasing the generational interval. However, conception rates in ewe lambs can be low. Nutrition is known to affect the reproductive success of ewe lambs, although the precise role of diet is largely unknown.

The mechanism is thought to function through effects on metabolic hormones, such as circulating insulin concentrations. Insulin promotes the secretion of reproductive hormones, known as gonadotrophins, which stimulate ovarian activity and encourage oestrus.

When this pathway was examined in post-calving dairy cattle, high starch diets were associated with a faster return to oestrus, which was thought to be caused by increased circulating insulin concentrations. In contrast, high fat diets were associated with reduced insulin concentrations and decreased conception rates. Dietary starch favours the propionate-producing pathway over acetate in the rumen, increasing insulin, whereas dietary fat reduces insulin synthesis and promotes cellular insulin resistance.

Hypothesis

| ↑ Starch (↑ insulin?) → Faster return to oestrus | v/s | ↑ Fat (↓ insulin?) → ↓ Conception rates |

The hypothesis we tested was that dietary manipulation of starch and fat would affect fertility in breeding ewe lambs through effects on circulating insulin concentrations. More specifically, high starch (insulin promoting) diets would hasten the onset of oestrous activity and increase conception rates in breeding ewe lambs when compared to those fed high fat (insulin suppressing), diets.

Methods
Two hundred and four Merino x Afrino ewe lambs with an initial live weight (mean ± SEM) of 44.1 ± 0.3 kg were randomly assigned to two dietary treatment groups, one high in starch and the other high in fat (n = 102 per treatment). Rations were fed for a continuous 60-day peri-conception period, (30 days prior to and after joining with the ram).

A base ration of a commercial pellet fed at 700 g/head/day was supplemented to form the two diets. The two diets contained similar levels of crude protein (high starch = 109 g/kg vs high fat = 108 g/kg) and metabolisable energy (high starch = 9.7 MJ/kg vs high fat = 10.1 MJ/kg).

Teaser wethers fitted with marking harnesses were introduced to the ewe lambs at day 0 to detect oestrous activity. On day 17 after the start of the nutritional treatments, the teaser wethers were removed and were replaced with rams fitted with marking harnesses that remained with the ewe lambs for 30 days.

Blood samples were taken from a subset of 20 ewes (per treatment) on days 0, 18 and 60 and analysed for plasma insulin concentration. All ewe lambs were body condition scored and weighed on days 0, 18 and 60 to monitor growth rates. Pregnancy detection on all of the ewe lambs was performed with ultrasonography on days 55 and 85. Body mass and insulin data were analysed by repeated measures ANOVA and fertility data was analysed by chi-square tests.

Results and take home messages
- In contrast to our hypothesis there was no overall effect of nutrition on the circulating concentration of insulin, despite insulin concentrations in the high starch group at day 18 compared to day 0 (Table 1; P<0.005).
- Body mass at joining and pre-joining growth rate did not differ between the diets, however the final body mass of the ewes on the high starch diet was significantly heavier than the group on the high fat diet (Table 1; P<0.001).

Table 1 Body mass (kg) and insulin concentration (µg/ml) of breeding ewes fed the high starch or high fat diet

<table>
<thead>
<tr>
<th>Day</th>
<th>High starch</th>
<th>High fat</th>
<th>SED</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Nutrition</td>
</tr>
<tr>
<td>Body mass</td>
<td>0 44.5 43.4 0.61 NS</td>
<td>18 47.4 46.4 0.64 0.67 &lt;0.001 &lt;0.001 NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulin</td>
<td>0 0.32 0.32 0.04 NS</td>
<td>18 0.50 0.40 0.07 &lt;0.005 &lt;0.005 NS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Points to note:
1. Diet had no overall effect on circulating insulin
2. There was no overall effect of diet on body mass at joining and pre-joining growth rate
3. Ewes on the high starch had a higher final body mass

Again, in contrast to our hypothesis, higher concentrations of insulin at joining, irrespective of nutritional treatment, had no effect on conception rates. There was also no effect of nutrition on the proportion of ewes displaying oestrous cycles (high starch = 78% vs high fat = 75%) or the number of twin pregnancies (high starch = 10% vs high fat = 5%).

Cycling ewes on the high starch diet had a higher conception rate than the ewes on the high fat diet (high starch = 96% vs high fat = 85%; P<0.05). This response however, was most likely not related to any changes in insulin, but rather the greater gains in body mass of the high starch group (high starch = 101.8 g/head/day vs high fat = 78.6 g/head/day; P<0.001).

Further supporting this, higher body mass at joining, irrespective of nutritional treatment, was associated with increased cycling rates (P<0.01), conception rates (P<0.05) and the twinning rate (P<0.01) (Figure 1).

![Figure 1](image_url)

Figure 1 The effect of joining body weight on reproductive parameters in ewe lambs. Significance levels: * P<0.05, ** P<0.01

Points to note:
1. Ewes with a higher body mass performed better on all parameters.
2. Ewes on the high starch diet had a higher final body mass.
Conclusion
In contrast to work in dairy cattle, our findings demonstrate that feeding a high starch diet to increase insulin concentrations and thereby improve ewe lamb fertility was not effective with the level of dietary starch used in this study.

However, the results do emphasise the importance of providing the necessary nutrition to achieve a suitable body mass for ewe lambs pre-joining, in order to maximise conception rates.

Acknowledgements
Wellard Agri Ltd for the ewe lambs and facilities and Lienert Australia Pty Ltd for the Megalac®.

Intramuscular fat percentage is correlated between muscles and with whole body fatness, but only in the loin.

Graham Gardner, D. Pethick and F. Anderson, Murdoch University WA

Introduction
Eating quality of lamb meat is essential for maintaining consumer demand and is strongly associated with intramuscular fat percentage (IMF%). On this basis, work is underway to develop systems for determining IMF% in Australian abattoirs using measurements taken from the loin. This assumes that loin IMF% would correlate strongly to IMF% within other muscles of the carcase, an assertion supported by work in beef, but not previously explored in lamb.

To further enhance the prediction of IMF% in other muscles, alternative biochemical indicators could be explored. Previous research has identified an association between IMF% in the loin and muscle oxidative capacity. If this association extended to other muscles, this would imply that knowledge of muscle type (indicated through colour) may further improve the prediction of IMF% in muscles beyond the loin. Muscle oxidative capacity can be indicated by certain oxidative enzymes as well as myoglobin concentration, with the red myoglobin pigment associated with colour in meat.

Therefore we hypothesise that IMF% in lamb will correlate between different muscles of the carcase, enabling eating quality prediction. Furthermore, we expect that increasing muscle oxidative capacity will be associated with increased IMF% in muscles other than just the loin.

Materials and methods
Pasture fed lambs (n=360) were slaughtered at a target carcase weight of 23kg in 2011. These lambs were from the Katanning site of the Sheep CRC Information Nucleus Flock and were the progeny of sires divergent for numerous production traits, including carcase fatness.

Within 4 hours post-mortem, muscle samples were collected from three sections of the carcase for analysis of myoglobin concentration, and oxidative enzyme activity: from the fore section, the M. supraspinatus and M. infraspinatus; from the saddle section, the M. longissimus lumborum (loin); and from the hind section, M. semimembranosus and M. semitendinosus.

Within 72 hours post-mortem, carcases were CT scanned to determine their fat percentage (CTfat%), and then the muscles mentioned above were sampled for IMF%. Partial correlations were determined for IMF% between muscles and with CTfat%, with these comparisons repeated to determine simple correlations.
Partial correlations between IMF%, myoglobin concentration, and oxidative enzyme activity within individual muscles were also determined. The partial correlations were all corrected for fixed effects including sex, sire type, and dam breed.

**Results and take home messages**

As has been found previously, the correlation in IMF% between the loin to the other muscles was fairly consistent (see Table 1) with values ranging between 0.34 and 0.40 (partial correlation coefficient).

There was a strong correlation between the m. supraspinatus and the m. infraspinatus in the fore section of the carcass, and the weakest correlations were those between the forequarter and hindquarter muscles.

Simple correlations demonstrated similar trends to the partial correlation coefficients.

The correlation of IMF% and CTfat% varied between muscles from 0.24 to 0.41 (partial correlation coefficient, Table 1), and was strongest in the loin.

This supports the correlated maturation of all fat depots throughout the body, and implies that a single point measurement of IMF% within the loin is adequate for predicting IMF%, and therefore eating quality within other muscles of the carcase.

This prediction could be further enhanced with the inclusion of an accurate measurement of carcase fatness, although it is likely that this would introduce bias in instances where selection indexes simultaneously target a reduction in back-fat and an increased IMF%, effectively uncoupling the biological correlation between these traits.

Within the loin there was a weak correlation (P<0.01) between IMF% and enzyme activity and myoglobin concentration, with partial correlation coefficients of 0.14.

Yet contrary to our hypothesis, this association was not evident in any of the other muscles tested. Therefore knowledge of muscle type, which could be indicated by its pigment colour association, is unlikely to further enhance prediction of IMF% in the carcase.

**Table 1** Partial (above diagonal) and simple correlation coefficients (below diagonal) between the IMF% in the m. semimembranosus (SM), m. semitendinosus (ST), m. supraspinatus (SS), m. infraspinatus (IS) and m. longissimus lumborum (LL), and for % carcase fat (CT fat%) measured using computed tomography in lamb.

<table>
<thead>
<tr>
<th></th>
<th>SM</th>
<th>ST</th>
<th>SS</th>
<th>IS</th>
<th>LL</th>
<th>CT fat%</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>1</td>
<td>0.42</td>
<td>0.3</td>
<td>0.38</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>ST</td>
<td>0.42</td>
<td>1</td>
<td>0.25</td>
<td>0.29</td>
<td>0.4</td>
<td>0.24</td>
</tr>
<tr>
<td>SS</td>
<td>0.41</td>
<td>0.3</td>
<td>1</td>
<td>0.68</td>
<td>0.34</td>
<td>0.29</td>
</tr>
<tr>
<td>IS</td>
<td>0.48</td>
<td>0.34</td>
<td>0.75</td>
<td>1</td>
<td>0.34</td>
<td>0.25</td>
</tr>
<tr>
<td>LL</td>
<td>0.45</td>
<td>0.47</td>
<td>0.45</td>
<td>0.45</td>
<td>1</td>
<td>0.41</td>
</tr>
<tr>
<td>CT fat%</td>
<td>0.24</td>
<td>0.32</td>
<td>0.36</td>
<td>0.31</td>
<td>0.48</td>
<td>1</td>
</tr>
</tbody>
</table>

All correlations are significantly different from zero (P <0.05)

Points to note:
1. IMF in the loin muscle was well correlated with IMF in other muscles of the carcass
2. Indicators of muscle biochemistry will not enhance the prediction IMF in other muscles

**Conclusion**

Measurement of IMF% in the loin enables prediction of IMF% in other muscles, suggesting scope for predicting their eating quality. Accurate measurement of whole carcase fatness will enhance this prediction, however indicators of muscle oxidative capacity will not.
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