**ABSTRACT:** Many grazing enterprises experience periods of feed abundance and shortage in an annual cycle. The paper demonstrates that ewes and cows with greater Fat EBVs are likely to be fatter at all times throughout the year. Thus, during periods of feed shortage, they are likely to take longer to reach threshold condition levels to begin supplementary feeding which represents a significant financial and time saving for producers. Genetically fatter ewes and cows are likely to have eaten more during periods of feed abundance. Thus, depending on the relative cost of feed during periods of abundance and shortage, they are not necessarily more efficient but may be more profitable.

**Keywords:** ewe; cow; fat; feed

**Introduction**

Australia’s environment for grazing industries is highly seasonal and, by world standards, low rainfall which is normally associated with greater annual variability, but Australia’s rainfall is also more variable than other countries (Nicholls et al. 1997).

Supplementary feed costs are one of the strongest key performance indicators for profit in grazing sheep and cattle industries. Young et al. (2011) demonstrated that whole-farm profit is very sensitive to liveweigh profile of ewes and that the optimum profile should be achieved through altering stocking rate and supplementary feeding of ewes. Tromf et al. (2011) reported that the uptake of “Lifetime Wool” guidelines to increase condition has resulted in a 12% increase in lamb marking, 14% increase in whole farm stocking rates and 43% decline in ewe mortality. However, supplementary feeding costs are a significant component of cost of production.

Traditionally, cycling in weight and body condition during the year has been viewed as an inefficient use of energy due to the cost of muscle and fat deposition and subsequent mobilization which increases energy requirements by 50% (Moore et al. 2009). However, in southern Australian grazing systems, energy availability in spring typically exceeds energy requirements. Thus, it seems advantageous to have animals that can utilize more of this relatively cheap feed by gaining more condition (muscle and fat) and then mobilize this when feed is expensive. Given that the difference in feed cost between times of abundance and shortage is likely to be greater than 50%, the system may become more profitable despite being less efficient.

In Australia in recent years through Cooperative Research Centre’s in Sheep and Beef there has been a focus on improving maternal productivity. This paper quantifies differences in time to trigger supplementary feeding in sheep and beef associated with genetic fatness.

**Materials and Methods**

**Sheep Maternal Central Progeny Test.** The sheep data herein is from the MCPT reported by Fogarty et al. (2005). 91 sires from 7 sire breeds were crossed to Merino or Corriedale ewes and the focus was on the performance of the first cross ewe progeny as prime lamb dams. Ewes were weighed and fat scored at key production times (4 times/year) from yearlings to weaning time of their 3rd parity.

The data was analyzed by fitting a linear mixed model in ASREML v3.0 (Gilmour et al. 2009). Briefly, fixed effects included cohort (5 levels), dam source (10 levels), reproductive status defined as having 27 levels (3 parities x dry, single or multiple lambs weaned) and time from first joining as a linear covariate (full description by Walkom et al. 2014). Random effects were cohort x year, sire breed, sire within breed, reproductive status x breed and reproductive status x sire. Additional random effects were interactions between the effects listed and linear regression on time and also spline curvature terms with 12 knot points. The primary aim was to quantify genetic variation in deviations from an intercept effect.

**Cattle Maternal Productivity: Research herd sub-project.** The research herds comprised cows that were selected either for Rib Fat or Net Feed Intake EBVs (Pitchford et al. 2014). The herds were run at the Western Australian Department of Agriculture and Food’s Vasse Research Centre and South Australian Research and Development Institute’s Struan Research Centre. Only the Fat “lines” are presented herein. These comprised 338 Angus cows selected as heifers from industry herds for either High-Fat (mid-parent EBV for Rib Fat in top 10% of breed) or Low-Fat (bottom 10% for Rib EBV). After their first joining, they were assigned either High or Low-Nutrition treatments which were designed to allow cows to fluctuate in condition throughout the year but for the High treatment to have 20% greater intake than Low akin to a Low and High stocking rate respectively.

The rib fat data was analyzed by fitting a linear mixed model (Gilmour et al. 2009) with fixed effects of site (Vasse or Struan), cohort (2 year intakes at each site), re-
productive status (8 categories describing weaning a calf or not at each of 3 parities), nutrition, line, the covariate of time from weaning and many interactions. Random effects included spline effects of time with 20 knot points and interactions with fixed effects and the time spline.

**Cattle Maternal Productivity: Industry herd sub-project.** Over 8000 Angus and Hereford cows in seedstock herds were ultra-sound scanned for body composition traits (loin eye muscle area, rib and rump fat depth, intramuscular fat depth) at pre-calving and weaning for their first 2 parities to generate 4 time points, PC1, W1, PC2 and W2 (Pitchford et al. 2014). In addition, yearling rib data was also accessed (Donoghue et al. 2014). The rib data was analyzed by fitting a linear mixed model (Gilmour et al. 2009) with fixed effects of contemporary group, age of the animal and date of measurement as covariates. The animal relationship matrix was fitted as the random effect. Correlations were estimated from the same effects analyzed as a series of bivariate models.

**Results**

**Sheep.** Fat score means for the 7 sire breeds are presented (Figure 1). There are clear differences between breeds in ewe body composition. However, the breeds are all close to parallel demonstrating no re-ranking of genetic effects on fat score. In addition, whilst between sire variance was observed for fat score, the sire variance in linear or spline deviations were negligible (Table 1). This implies that the genetic correlation between fat scores of ewes at different times of the year and across years is close to unity. Comparable results were also observed for ewe weight (Walkom et al. 2014).

![Figure 1](image1.png)

**Figure 1.** Predicted fat score profiles for the major first cross sire breeds using spline prediction estimates. Sire breeds in order from fattest to leanest: Booroola Leicester, Border Leicester, Coopworth, White Suffolk, Finnish Landrace, Corriedale, East Friesian.

<table>
<thead>
<tr>
<th>Term</th>
<th>Intercept</th>
<th>Linear</th>
<th>Curvature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Fixed</td>
<td>Fixed</td>
<td>0.505</td>
</tr>
<tr>
<td>Cohort</td>
<td>Fixed</td>
<td>0.014</td>
<td>0.000</td>
</tr>
<tr>
<td>Cohort by year</td>
<td>0.101</td>
<td>0.005</td>
<td>3.524</td>
</tr>
<tr>
<td>Dam Source</td>
<td>Fixed</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>Reproductive status</td>
<td>Fixed</td>
<td>0.012</td>
<td>0.119</td>
</tr>
<tr>
<td>Sire breed</td>
<td>0.090</td>
<td>0.002</td>
<td>0.001</td>
</tr>
<tr>
<td>Sire</td>
<td>0.027</td>
<td>0.003</td>
<td>0.001</td>
</tr>
<tr>
<td>Reprod. x sire breed</td>
<td>0.002</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Reprod. x sire</td>
<td>0.063</td>
<td>0.004</td>
<td>0.001</td>
</tr>
<tr>
<td>Residual</td>
<td></td>
<td></td>
<td>0.340</td>
</tr>
</tbody>
</table>

Table 1. Partitioning of variation in fat score profiles across the first three reproductive cycles

In a similar analysis in a composite flock, Walkom (unpublished) found the genetic correlation between post-weaning fat and adult fat was 0.80 (SE=0.10) and with adult condition score was 0.73 (0.13).

**Cattle.** Rib fat adjusted for weight for the High and Low-Fat lines under High and Low-Nutrition are presented for cows that weaned a calf in each of the 3 parities (Figure 2). At joining, the High and Low-Fat lines differed in fat depth by 0.8mm. The nutrition treatments were applied after joining so divergence in fat depth was apparent for almost 6 months prior to calving. On Low-Nutrition, at the time of weaning their 3rd calf, the difference between lines increased to 2.5mm. On High-Nutrition the difference increased to 3.4mm. While the differences increased over time, the variation in the lines was very similar so the fat profiles were almost parallel (Figure 2) and probably would have been so if analyzed on the log scale. There are two sources of evidence to support this. In the analysis, the line x spline term was very small and the nutrition x line x spline converged to zero (not presented).

![Figure 2](image2.png)

**Figure 2.** Predicted rib fat depth with weight as a covariate for the High-Fat (black) and Low-Fat (grey) lines on High-Nutrition (dashed) or Low-Nutrition (solid lines).
The research herds had limited numbers of cows but many measurements. In contrast, the industry herd sub-project had just 2 measurements per year, but a large number of cows (2740-4840 depending on the measurement). Donoghue et al. (2014) estimated genetic correlations between rib fat of cows at 5 time points (Table 2). The yearling and first pre-calving measurements were highly genetically correlated as expected as they were only about 3 months apart. These measurements were moderate to highly correlated with rib fat once they had weaned a calf. However, the rib fat on all cow measurements (W1, PC2, W2) were very highly correlated with each other (>0.93).

### Table 2. Phenotypic (above diagonal) and genetic (below) correlations (SE) between rib fat depth of cows as yearlings, heifer pre-calving, weaning of first calf, cow pre-calving, and weaning of second calf.

<table>
<thead>
<tr>
<th></th>
<th>Yearling</th>
<th>PC1</th>
<th>W1</th>
<th>PC2</th>
<th>W2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearling</td>
<td>0.62 (0.01)</td>
<td>0.45 (0.02)</td>
<td>0.44 (0.02)</td>
<td>0.43 (0.02)</td>
<td></td>
</tr>
<tr>
<td>PC1</td>
<td>0.57 (0.03)</td>
<td>0.46 (0.02)</td>
<td>0.50 (0.02)</td>
<td>0.44 (0.02)</td>
<td></td>
</tr>
<tr>
<td>W1</td>
<td>0.63 (0.05)</td>
<td>0.63 (0.06)</td>
<td>0.73 (0.01)</td>
<td>0.63 (0.01)</td>
<td></td>
</tr>
<tr>
<td>PC2</td>
<td>0.63 (0.06)</td>
<td>0.76 (0.06)</td>
<td>0.97 (0.02)</td>
<td>0.58 (0.02)</td>
<td></td>
</tr>
<tr>
<td>W2</td>
<td>0.60 (0.07)</td>
<td>0.63 (0.08)</td>
<td>1.00 (0.00)</td>
<td>0.93 (0.04)</td>
<td></td>
</tr>
</tbody>
</table>

**Discussion**

The results demonstrate that over multiple parities, there is negligible re-ranking of the genetic merit of sheep and cattle for fat depth. At the start of the Maternal Productivity Project it was not known whether there was genetic variation in “ability to maintain body reserves”. It is believed that the results herein are compelling that those animals that are genetically fatter during times of feed shortage, are also likely to be genetically fatter during times of abundant feed. This finding facilitates a way to estimate an economic value for fat depth independent to that associated with reproduction where the focus has been in the past.

Graham (2006) described a 0-5 condition scores in cows and stated that cows in condition score 2 have approximately 6mm and cows in score 3 have approximately 14mm subcutaneous fat over the rump. Based on conversions from this project (Donoghue et al. 2014), rib fat depth measurements are commonly 20% less than rump fat. Thus, 6 and 14mm over the rump correspond to 5 and 11mm respectively. Lee et al. (2014) reported that 1mm extra carcass Rib-EBV is related to 13.5% greater rib fat depth in cows. Thus, if the average cow has 11mm rib fat, then a +1mm EBV (1 standard deviation) cow would have 12.5mm.

The results herein provide evidence that cows that differ genetically in fatness decline in fat or condition at the same rate (parallel fat profile). Thus, if there is a threshold level when supplementary feeding starts, then the one that is fatter at the start will take longer to reach the feeding threshold. This is represented in Figure 3 where it is assumed that condition score 2 is the threshold and the herd begins in good condition (score 3). If the average cow takes 2 months to lose a score, then a genetically fatter cow takes 15 days longer to reach the same threshold. Importantly, Walkom (unpublished) has demonstrated in a maternal composite sheep flock that the effect of an additional 1 genetic standard deviation in fat depth in had a similar effect on delaying the need for supplementary feeding of ewes as cows presented herein. This 15 days difference can have an economic value assigned relatively simply by costing supplementary feed, labor, maintenance and depreciation of machinery during that period.

![Figure 3. Effect on an additional 1mm Rib Fat EBV on time taken to trigger supplementary feeding when average cows are losing condition from score 3 to 2 out of 5.](image)

An important point to note is that the additional fat of the +1mm EBV is associated with greater energy intake during times of feed abundance. Work from the same project where cows had feed intake at pasture measured (Heb- hart et al. 2014) has demonstrated that during periods of feed abundance, genetically fatter cows have greater feed intake. Additional evidence for this is also that a significant correlated response to selection for residual feed intake was also associated with differences in subcutaneous fat depth. However, while this has a cost, when feed is abundant, it is relatively cheap and often poorly utilized so the extra energy stored as fat is not very expensive.

**Literature Cited**


