Genetic parameters for body condition scores and live weights for cows in New Zealand beef herds

N.G. Cullen1 & A.M. Boyd2

1 AgResearch Ruakura, Private Bag 3123, Hamilton 3240, New Zealand
neil.cullen@agresearch.co.nz (Corresponding Author)
2 AgResearch Invermay, Private Bag 50034, Mosgiel 9053, New Zealand

Summary

This paper summarises results from a Beef + Lamb New Zealand Genetics trial studying maternal productivity in New Zealand (NZ) beef herds. There are four herds on three farms in the southern half of the South Island of NZ involved, two being Angus herds while the other two are Herefords. Pedigree and performance data is recorded on these farms allowing their data to be used for genetic analysis. Body Condition Score (BCS) and live weight (LWt) on the cows is recorded three times per year; prior to calving, at drafting for mating and at weaning. Calf birthdate, calf sex, dam and sire, and calf weaning weight (WWt) were also recorded. Genetic parameters (including heritability, repeatability and genetic and phenotypic correlations) were estimated for and between BCS and LWt at each of the three times of the year, and also as single traits across seasons. WWt was also analysed with both BCS and LWt recorded at each time point. Heritabilities were consistent with those reported elsewhere, with BCS having a lower value than that for LWt. Genetic correlations between BCS and LWt were small but positive. For WWt analysed with LWt, genetic correlations were high as expected but the genetic correlations between WWt and BCS were not significantly different from 0 at calving and weaning but negatively corrected with BCS at weaning.

Keywords: beef cattle, maternal, body condition, genetic parameters

Introduction

In a pastoral, seasonal animal production system which is predominant in New Zealand (NZ), there are inevitably periods when the levels of nutrition available from pasture are not sufficient to maintain an animal in its most productive state. These periods of under-nutrition include winter (pre-calving) and early lactation in spring where pasture growth has not yet increased to meet the demands of milk production. Periods of dry weather can also lead to poor pasture growth and further stress on the cow-calf system.

One source of extra nutrients is the animal’s own reserves of readily mobilisable nutrients stored as fat, including adipose tissue. Although some of these reserves are stored internally, one measure of the level of accessible nutrients is Body Condition Score (BCS), a visual and tactile score of the level of subcutaneous fat along the backbone of an animal. The ability to deposit and utilise these stores may assist a cow to maintain herself, grow her calf and recover from calving before the start of the next production cycle at the subsequent mating, and contribute to the cow’s overall productive efficiency. Johnston et al. (1996) propose that BCS should be included in a multiple-trait model including LWt and the breeding values included in index selection to maintain cow live weight and body condition at levels which add to the overall profitability of the breeding herd.
The longer-term aim of the work described here is to ascertain whether BCS does have a role in predicting cow productivity; affecting pregnancy success and longevity in the herd.

**Material and methods**

Routine on-farm management tasks in recorded herds means that cows have to be brought to the yards at certain periods of the year. Opportunities were taken to record BCS and live weight (LWt) at three time-points with minimal interruption to whatever procedure was being carried out on the day. These data were recorded prior to Calving (August-September), at drafting for Mating (November-December) and at Weaning (March-April of the subsequent year). Calf weaning weight (WWt) is routinely collected at Weaning when calves are approximately 5-7 months old. DNA samples were taken from all cows at a convenient opportunity during one of these yard visits. For calves, the preferred time for DNA-sampling is at Mating when the calves are lighter and much easier to restrain.

BCS was measured to the standards produced by Beef + Lamb NZ (http://www.beeflambnz.com/knowledge-hub/factsheets/beef-cow-body-condition-scoring). Scores can range from 1 – 10 with half-scores used. All scoring is performed whilst cows are in the race leading to the crush where animal live weight is recorded.

**Herds**

The four herds used for these analyses (where pedigree is recorded) are all based in the South Island of NZ. Their details are described in Table 1.

*Table 1. Details of the four herds used in this study including farm, location, website, breed and numbers of cows present at the start of Calving.*

<table>
<thead>
<tr>
<th>Farm</th>
<th>Location</th>
<th>Website</th>
<th>Breed</th>
<th>N cows at calving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haldon Station</td>
<td>Mackenzie Basin</td>
<td>haldonstation.co.nz</td>
<td>H</td>
<td>~340</td>
</tr>
<tr>
<td>Haldon Station</td>
<td>Mackenzie Basin</td>
<td>haldonstation.co.nz</td>
<td>A</td>
<td>~130</td>
</tr>
<tr>
<td>Orari Gorge Station</td>
<td>South Canterbury</td>
<td><a href="http://www.orarigorge.co.nz">www.orarigorge.co.nz</a></td>
<td>H</td>
<td>~240</td>
</tr>
<tr>
<td>Mount Linton Station</td>
<td>Southland</td>
<td><a href="http://www.mountlinton.co.nz">www.mountlinton.co.nz</a></td>
<td>A</td>
<td>~750</td>
</tr>
</tbody>
</table>

\(^{1}\) A = Angus, H=Hereford

The numbers of cows recorded over 3 - 4 seasons along with summary statistics for BCS and LWt are summarised in Table 2 (in Appendix). These are raw means where the cow age proportions can change from farm to farm, from year to year and from one recording time to the next. From an individual cow viewpoint, both BCS and LWt increased markedly from Calving to Mating (in spite of LWt losses due to weight of conceptus). There was little change in BCS from Mating to Weaning with both increases and decreases whilst overall, there was a small increase for LWt over the same period.

**Statistical analyses**
For genetic analysis, a file summarising all BCS and LWt collected from Weaning 2014 onwards was produced along with the required fixed effects. A record year was defined as starting at calving and annual records where a cow had twins were removed from the file. A separate file was produced for animals born since 2005 with all WWt data recorded; this meant that the great proportion of cows had all their progeny WWt included. A pedigree file was also produced with a maximum of four generations of ancestors for each animal.

The data was analysed with ASReml (Gilmour et al., 2009) with a variety of structures and models. Univariate models were run for each of the BCS and LWt recorded at each of the three time points before running all six traits in one run. Subsequently all BCS and LWt traits were stacked such that there were just two traits with extra fixed effects added to fully describe the model. The final model appended the cow’s own WWt and all animals with a WWt born since 2005 to the initial structure to estimate the relationship of mature cows’ BCS and LWt with WWt.

Models

For Calving: CowStatus@Calving(Pregnant/did not calve) + if(Pregnant), CalvingDay devn from CGp mean,
For Mating: CowStatus@Mating(Calved, – rearing a calf/calved, – calf died/did not calve) + if(Calved), CalvingDay devn from CGp mean,
For Weaning: same as for Mating with CowStatus updated to include calf deaths post-mating, CGp(Cow): Farm.Breed.RecDate.Mob.CowAge@start_of_year (CowAge1-7+),
Random effects (Cow): Animal (genetic) + permanent environment effect of the Cow,
For WWt: DamAge(2-7+) + CalfSex + Calf_Age@Weaning (deviated from CGp mean),
CGp(Calf): Farm.Breed.Year_of_birth,
Random effects (Calf): Animal (genetic) + dam (genetic) + permanent environmental effect of dam.

When BCS and LWt data were stacked, additional effects added were RecordYear + CowAge1-7+ + Time (Calving/Mating/Weaning) with CGp(Cow) redefined to Farm.Breed.RecDate.Mob; with appropriate CowStatus and CalvingDay devn as above, for each Time. An extra random term was fitted to account for individual animal effects common to a RecordYear,

Results and Discussion

The genetic parameters for BCS and LWt recorded at the three time-points are shown in Table 3 (Appendix). Heritabilities for BCS ranged from 0.14 (Weaning) to 0.16 (s.e. 0.03) (repeatabilities all 0.38, s.e. 0.02) and for LWt from 0.30 to 0.38 (Calving) (s.e. 0.04) (repeatabilities 0.71 to 0.74, s.e. from 0.01 to 0.02). The BCS heritabilities were in good agreement with those reported by Johnston et al., (1996) for three breeds, ranging from 0.14 to 0.21, and with the 0.16 estimated by Nephawe et al., (2004). The repeatability estimates for BCS were also in close agreement with both the aforementioned studies. For LWt, the heritabilities calculated from these data were less than those reported by the previous two studies but the repeatabilities were in close agreement. Angus Australia reports that they use a heritability of 0.40 for Mature Cow LWt in Angus BREEDPLAN (www.angusaustralia.com.au/breedplan/resources/heritability-of-traits). The genetic correlations between the three BCS scores were very similar (0.76 to 0.83, s.e. from 0.05 to
0.08), whilst the phenotypic correlations ranged from 0.41 to 0.61 (s.e. 0.02). For LWt, the
genetic correlations were high from 0.90 to 0.96 (s.e. 0.01) and the phenotypic from 0.72 to
0.85 (s.e. 0.01). Both BCS and LWt had the highest correlations within traits when recorded
at Mating and Weaning in the results above; this suggests that one of these recording times
could be omitted with little impact on genetic progress.

The highest correlations between the BCS and LWt traits were also for measures taken
at Mating and Weaning, and these two periods provided the only non-significant genetic
correlations between pairs of traits recorded at the same time. For Mating, the genetic
correlation between BCS and LWt was 0.25 ± 0.10 (phenotypic 0.57 ± 0.01) and at Weaning
the correlations were very similar with the genetic being 0.28 ± 0.10 and the phenotypic 0.52
± 0.01. When the stacked data was analysed, BCS had a heritability and repeatability (across
and within years) of 0.22 ± 0.02, 0.35 ± 0.01 and 0.51 ± 0.01, respectively. For LWt, the
corresponding estimates were 0.41 ± 0.03, 0.71 ± 0.01 and 0.78 ± 0.01. These results match
those reported by others and the LWt heritability is consistent with that used by Angus
Australia for Mature Cow LWt.

The genetic and phenotypic correlations of WWt with the BCS and LWt traits were
investigated using both structures; three measures per year or all measures condensed into
one. As would be expected, WWt analysed with LWt gave high genetic correlations; those
with LWt at Calving and Mating were 0.73 ± 0.06 and 0.69 ± 0.06 respectively while the
phenotypic correlations were consistent across time at 0.43 to 0.44. For the single-trait LWt
model, the genetic correlation was 0.72 ± 0.06.

With WWt and BCS, the picture is uncertain; only one of the genetic correlations was
significant at the 5% level with two of the three being negative. For BCS at Calving, the
result was -0.07 ± 0.11, at Mating 0.11 ± 0.11 and for Weaning -0.25 ± 0.10. The
corresponding phenotypic correlations were 0.07 ± 0.02, 0.14 ± 0.02 and 0.12 ± 0.02. For the
single-trait BCS model, the genetic correlation was -0.16 ± 0.09.

These results are a preliminary estimate of the genetic parameters as more data are
being collected; the last data included here were collected at Weaning in March 2017. It was
not possible to confirm the findings of Morris & Cullen (1985) that the Hereford and Angus
cows of that period had different mean BCS as the Herefords and Angus at Haldon Station
are managed as distinct entities for the whole year. Analyses which include the correlations
of the maternal effect for WWt with the direct effects for BCS should be considered in future
analyses.

Mt Linton also has a commercial herd which calves ~2,000 cows; this herd is also part
of this study but DNA collected will be used to predict pedigrees for any future genetic
analysis. There is also another commercial farm (Longspur) in Canterbury which runs mainly
Herefords, calving ~250 cows. These two herds will allow genetic parameters for longevity,
for example, to be calculated for animals in commercial herds, where decisions on culling are
not based on objective data such as breeding values, apart from pregnancy status.
Acknowledgements

This is a Beef + Lamb New Zealand Genetics project funded by the Ministry for Business, Innovation and Employment and Beef + Lamb Zealand. Particular recognition is given to the four farm owners, managers and staff who allowed us to impose extra tasks onto their already busy schedules.

List of References


## Appendix

**Table 2. Summary by Herd and Breed of the total number of individual cows scored and a summary of records, mean Body Condition Score (BCS) and live weight (LWt) recorded prior to Calving, prior to Mating and at Weaning.**

<table>
<thead>
<tr>
<th>Herd</th>
<th>Breed</th>
<th>Total N cows</th>
<th>Total N records</th>
<th>Calving N records</th>
<th>Calving Mean BCS</th>
<th>Calving Mean LWt</th>
<th>Mating N records</th>
<th>Mating Mean BCS</th>
<th>Mating Mean LWt</th>
<th>Weaning N records</th>
<th>Weaning Mean BCS</th>
<th>Weaning Mean LWt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orari Gorge</td>
<td>H</td>
<td>4</td>
<td>215</td>
<td>5</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>902</td>
<td>.8</td>
<td>9</td>
<td>6</td>
<td>791</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>902</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>5</td>
<td>9</td>
<td>6</td>
<td>8</td>
<td>791</td>
</tr>
<tr>
<td>Haldon</td>
<td>H²</td>
<td>7</td>
<td>378</td>
<td>5</td>
<td>4</td>
<td>6</td>
<td>5</td>
<td>129</td>
<td>.5</td>
<td>5</td>
<td>147</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>2</td>
<td>9</td>
<td>8</td>
<td>2</td>
<td>376</td>
</tr>
<tr>
<td>Haldon A</td>
<td></td>
<td>2</td>
<td>2</td>
<td>122</td>
<td>6</td>
<td>129</td>
<td>2</td>
<td>7</td>
<td>2</td>
<td>5</td>
<td>376</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>9</td>
<td>0</td>
<td>393</td>
<td>.2</td>
<td>4</td>
<td>.3</td>
<td>3</td>
<td>.1</td>
<td>2</td>
<td>348</td>
<td>7.2</td>
</tr>
<tr>
<td>Mt Linton A</td>
<td></td>
<td>1</td>
<td>6</td>
<td>827</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>348</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>5</td>
<td>218</td>
<td>.9</td>
<td>4</td>
<td>7</td>
<td>9</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>

1 A = Angus, H = Hereford
2 Haldon Hereford cows are first mated at 2 years of age, all other herds at 1 year old.
Table 3. Genetic parameters for BCS and LWt recorded at three time-points, Calving, Mating and Weaning; heritabilities ($h^2$) in bold on the diagonal followed by repeatability, with genetic correlations on the lower off-diagonal and phenotypic correlations on the upper off-diagonal. All estimates are followed by their standard errors.

<table>
<thead>
<tr>
<th></th>
<th>BCS</th>
<th>LWt (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Calving</td>
<td>Mating</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calving</td>
<td><strong>0.16 ± 0.03</strong></td>
<td>0.37 ± 0.02</td>
</tr>
<tr>
<td>Mating</td>
<td>0.76 ± 0.08</td>
<td><strong>0.16 ± 0.03</strong></td>
</tr>
<tr>
<td>Weaning</td>
<td>0.79 ± 0.08</td>
<td>0.83 ± 0.05</td>
</tr>
<tr>
<td>Calving</td>
<td>0.17 ± 0.13</td>
<td>0.08 ± 0.11</td>
</tr>
<tr>
<td>Mating</td>
<td>0.14 ± 0.12</td>
<td>0.25 ± 0.10</td>
</tr>
<tr>
<td>Weaning</td>
<td>-0.01 ± 0.12</td>
<td>0.13 ± 0.11</td>
</tr>
</tbody>
</table>