Survival analysis for length of productive life of beef cows
Karin Meyer
Animal Genetics and Breeding Unit, University of New England, Armidale NSW 2351

Objectives
Pilot study to examine:
- Patterns of survival
- Risk factors for culling of beef cows
- Genetic variation in length of herd life

Basics of Survival Analysis
- Central variable: hazard \( h_i(t) \) — probability that cow \( i \) is culled at time \( t \) (given she survived that far)
- Fit non-linear model: \( h_i(t) = h_0(t) \exp\{w_i \theta\} \)
- Assumption: \( h_i(t) \) for different \( w_i \) are proportional

Data
- 1.7 \times 10^6 pedigree records for Angus
- Approximately measure for length of productive life (LPL): assign calves to rearing dam
- LPL = interval between birth of first & last calf
- Discard LPL < 10 months
- Use only cows with ≥2 calves
- Flag censored records
- Use only herds with ≥ 40% AI sires

Model
- Fixed effects:
  - Age of cow at birth of 1st calf
  - Year of birth of 1st calf
  - Month of birth of 1st calf
  - Month of birth of last calf
  - Cow changed herd (Y/N)
  - Cow raised ET calf (Y/N)
  - Cow was an ET calf (Y/N)
  - No. sires raised (0,1,2+)
  - No. herds/cow's sire (1.2-5.6+)
  - Stage (22 classes for LPL: 10-14, 15-22, 23-27, ..., 136-144)
  - Herd
- Random effects:
  - Sire; pedigrees on sires & MGS
  - Herd-year of birth of 1st calf

Analyses
- Cox model
  - Shape of \( h_0(t) \) not specified
- Weibull model
  - \( h_0(t) = \rho \lambda (\lambda t)^{\beta-1} \)
  - \( \rho, \lambda, \beta \): parameters of Weibull distribution
- Software: Survival Kit 5

Results
Baseline hazard \( h_0(t) \)
- Clear annual pattern
- ~ 7 months of low risk → raising a calf
- ~ 5 months of high risk

Survival curve for \( w_i = 0 \)
- Chance of a cow to have LPL of at least
  - 24 months → 79%
  - 48 months → 50%
  - 72 months → 28%
- Weibull model:
  - W1: single curve
  - W6+S22: 6-part curve + stage effect → better fit

Fixed risk factors
- Relative risk or risk ratio (RR)
  - Pick 'reference' level \( r \) → largest subclass
  - RR → multiplicative effect relative to \( r \)
  - RR < 0.7
  - Raising an ET calf: 0.57
  - Being a bull dam: 0.44 for 2+ sons
  - RR > 1.3
  - Calving out of season: Jan & Feb
  - First calf born after 37 months of age

Variances & approximate heritability

<table>
<thead>
<tr>
<th>Model</th>
<th>Herd-year</th>
<th>Sire</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>0.213</td>
<td>0.028</td>
</tr>
<tr>
<td>W6+S22</td>
<td>0.195</td>
<td>0.047</td>
</tr>
</tbody>
</table>

Conclusions
- Survival analysis for beef cattle is challenging
  - No herd inventory recording
  - Partial confounding: sires & herds
- Few risk factors identified
- Data structure restricts modelling
- Some genetic differences between sires in LPL of daughters