Age-Season Standardization

Dr. Michael M. Schutz

Canadian Beef Improvement, Inc.

A report on research conducted at AIPL, USDA-ARS, Beltsville, MD (financial support from the National Association of Animal Breeders, Columbia, MO).
Background

Former adjustment factors for calving age and season and their interaction were almost 20 years old:

- 1974 for milk and fat
- 1979 for protein for Holsteins (fat factors used for other breeds)
Background

- Management changes may have resulted in:
  - Earlier maturity of cows
  - Less effect by summer heat and humidity

- Present factors developed from models that didn’t consider relationships or differences arising from genetic trend
Research Objectives

- Estimate adjustment factors for milk, fat, and protein with animal models and relationships
- Account for changes over time
- Determine the effect of parity on adjustment factors (age within parity)
- Examine the impact of adjusting for previous and present days open
Data

- Calving ages of 18 to 200 months
- Cows milked 2x

<table>
<thead>
<tr>
<th>Breed</th>
<th>Records Milk, Fat</th>
<th>Records Protein</th>
<th>Cows Milk, Fat</th>
<th>Cows Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ayrshire</td>
<td>554,498</td>
<td>175,143</td>
<td>200,752</td>
<td>73,966</td>
</tr>
<tr>
<td>Brown Swiss</td>
<td>689,340</td>
<td>260,309</td>
<td>240,706</td>
<td>104,622</td>
</tr>
<tr>
<td>Guernsey</td>
<td>1,721,872</td>
<td>370,065</td>
<td>654,876</td>
<td>166,261</td>
</tr>
<tr>
<td>Holstein</td>
<td>36,669,120</td>
<td>16,762,036</td>
<td>13,647,452</td>
<td>7,314,878</td>
</tr>
<tr>
<td>Jersey</td>
<td>2,674,867</td>
<td>1,198,587</td>
<td>934,790</td>
<td>472,948</td>
</tr>
<tr>
<td>Milk. Shorthorn</td>
<td>86,174</td>
<td>30,575</td>
<td>34,132</td>
<td>13,692</td>
</tr>
</tbody>
</table>
Percentages of Holstein calvings by month and over time periods for regions 3 & 6.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>JAN</td>
<td>8.5</td>
<td>8.5</td>
<td>8.4</td>
<td>8.1</td>
<td>8.4</td>
</tr>
<tr>
<td>MAR</td>
<td>7.1</td>
<td>7.2</td>
<td>7.7</td>
<td>8.1</td>
<td>8.0</td>
</tr>
<tr>
<td>MAY</td>
<td>5.0</td>
<td>5.5</td>
<td>6.3</td>
<td>6.8</td>
<td>6.7</td>
</tr>
<tr>
<td>JUL</td>
<td>8.5</td>
<td>9.1</td>
<td>9.2</td>
<td>9.0</td>
<td>8.9</td>
</tr>
<tr>
<td>SEP</td>
<td>11.9</td>
<td>10.4</td>
<td>9.5</td>
<td>9.4</td>
<td>9.2</td>
</tr>
<tr>
<td>NOV</td>
<td>10.2</td>
<td>9.9</td>
<td>9.3</td>
<td>9.2</td>
<td>9.1</td>
</tr>
</tbody>
</table>
Average ages at calving for Holsteins by month and over time periods for regions 3 & 6.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>JAN</td>
<td>55.4</td>
<td>54.8</td>
<td>53.9</td>
<td>51.5</td>
<td>49.4</td>
</tr>
<tr>
<td>MAR</td>
<td>59.6</td>
<td>56.9</td>
<td>54.8</td>
<td>51.0</td>
<td>49.1</td>
</tr>
<tr>
<td>MAY</td>
<td>59.0</td>
<td>57.0</td>
<td>55.1</td>
<td>51.2</td>
<td>49.0</td>
</tr>
<tr>
<td>JUL</td>
<td>54.0</td>
<td>52.9</td>
<td>53.2</td>
<td>51.7</td>
<td>50.7</td>
</tr>
<tr>
<td>SEP</td>
<td>50.8</td>
<td>50.9</td>
<td>50.4</td>
<td>49.1</td>
<td>48.3</td>
</tr>
<tr>
<td>NOV</td>
<td>53.8</td>
<td>53.6</td>
<td>53.2</td>
<td>50.5</td>
<td>49.2</td>
</tr>
</tbody>
</table>
Animal Model

\[ Y = TRML + TRA + TD_C + TD_P + H + P + G + E \]

- \( Y \) = Yield (milk, fat, protein)
- \( T \) = Time
- \( R \) = Region
- \( M \) = Month of Calving
- \( L \) = Parity group
- \( A \) = Age Class
- \( D_C \) = Current days open
- \( D_P \) = Previous days open
- \( H \) = Herd-year
- \( P \) = Permanent environment
- \( G \) = Animal
- \( E \) = Residual error
Mixed Model Equations

\[ Y = TRML + TRA + TD_C + TD_P + H + \begin{array}{lll} P & + & G & + & E \\ \hline & & X & & \end{array} \]

\[ X'X \quad X'Z_P \quad X'Z_A \quad \begin{bmatrix} B \\ u_P \end{bmatrix} = \begin{bmatrix} X'Y \\ Z_P'Y \end{bmatrix} \]

\[
\begin{bmatrix}
X'X & X'Z_P & X'Z_A \\
Z_P'X & Z_P'Z_P + I & Z_P'Z_A \\
Z_A'X & Z_P'Z_A & Z_P'Z_P + A^{-1} k_2
\end{bmatrix}
\]

\[ k_1 = \frac{\sigma_e^2}{\sigma_P^2} \quad k_2 = \frac{\sigma_e^2}{\sigma_A^2} \]
Solving Equations

- Westell parent grouping
- Iteration on data
- Gauss-Seidel and Jacobi Iteration
- Iteration until average change in solutions was $< 1 \times 10^{-9}$ (about 400-500 rounds)

<table>
<thead>
<tr>
<th>Number of records and effects for regions 3 &amp; 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRML</td>
</tr>
<tr>
<td>TRA</td>
</tr>
<tr>
<td>$T_{D_C}$</td>
</tr>
<tr>
<td>$T_{D_P}$</td>
</tr>
</tbody>
</table>
# Age-Parity Classes

<table>
<thead>
<tr>
<th>Parity 1</th>
<th>Parity 2</th>
<th>Parity 3</th>
<th>Parity 4</th>
<th>Parity 5</th>
<th>Parity 6+</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-21</td>
<td>28-33</td>
<td>40-46</td>
<td>52-60</td>
<td>64-73</td>
<td>76-86</td>
</tr>
<tr>
<td>22-23</td>
<td>34-35</td>
<td>47-48</td>
<td>61-63</td>
<td>74-77</td>
<td>87-96</td>
</tr>
<tr>
<td>24</td>
<td>36</td>
<td>49-50</td>
<td>64-65</td>
<td>78-80</td>
<td>97-120</td>
</tr>
<tr>
<td>25</td>
<td>37</td>
<td>51-52</td>
<td>66-68</td>
<td>81-84</td>
<td>121-144</td>
</tr>
<tr>
<td>26</td>
<td>38</td>
<td>53-54</td>
<td>69-71</td>
<td>85-91</td>
<td>145-200</td>
</tr>
<tr>
<td>27-28</td>
<td>39-40</td>
<td>55-56</td>
<td>72-77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29-31</td>
<td>41-43</td>
<td>57-58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32-35</td>
<td>44-49</td>
<td>59-63</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Days Open

- Effects of calving age are influenced largely by calving interval

- Previous days open
  - Cows calving at early ages within parity are often disadvantaged by short days open in previous parities
  - Verified by subsequent calving date

- Current days open
  - May be correlated to previous days open
  - Cows calving late more likely to remain open
# Average Days Open

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>123</td>
<td>131</td>
<td>131</td>
<td>129</td>
<td>131</td>
</tr>
<tr>
<td><strong>Holstein</strong> MI, OH, IN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>120</td>
<td>127</td>
<td>130</td>
<td>130</td>
<td>132</td>
</tr>
<tr>
<td>3+</td>
<td>124</td>
<td>133</td>
<td>138</td>
<td>138</td>
<td>139</td>
</tr>
<tr>
<td>1</td>
<td>128</td>
<td>131</td>
<td>127</td>
<td>125</td>
<td>120</td>
</tr>
<tr>
<td><strong>Jersey</strong> National</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>123</td>
<td>126</td>
<td>124</td>
<td>120</td>
<td>117</td>
</tr>
<tr>
<td>3+</td>
<td>124</td>
<td>128</td>
<td>128</td>
<td>125</td>
<td>122</td>
</tr>
</tbody>
</table>
Calculation of Adjustment Factors

- Age solutions within parity (for each breed, time, region, and trait) must be smoothed by linear and quadratic regression of age class solutions on average ages of the classes.

- Intercepts from the regression are added to the month by parity solutions (for each breed, time, region, and trait) for computing ease.
Calculation of Adjustment Factors

- Solutions for previous days open (by breed, time, region, and trait) were smoothed by linear and quadratic regression of days open solutions on average days open per class.
  - joint point at 150 days open
    - \((\text{days open} - 150)^2\)
Calculation of Adjustment Factors

- Multiplicative adjustment factors are calculated on the fly for each 305 day 2X record as:

  \[ \text{yield}_{\text{base}} + \text{month} + \text{age} + \text{previous days open} \]

  \[ \text{yield}_{\text{base}} = \text{avg. yield of mature cows for a breed, region, and time period.} \]
Calculations

Holstein cow calving at 36 months in Parity 2 in JAN, 1992 in Indiana after being open 60 days in Parity 1.

\[
\text{yield}_{\text{base}} = 19550.9 \quad \text{month} = -7399.24 \\
\text{age} = 268.366 \times (36) + -2.5745 \times (36^2) = 6324.624 \\
\text{DOP} = -2502.06 + 32.1617 \times (60) + -0.09426 \times (60^2) \\
\quad + 0.11338 \times (0^2) = -911.694
\]

\[
\text{Factor} = \frac{19550.9}{19550.9 - 7399.24 + 6324.624 - 911.694} = 1.113
\]
Base Age

- Mature yield appears to be reached earlier.
- Ayrshires, Brown Swiss, Guernseys, and Holsteins had maximum yield at 72-77 months in 4th parity.
- Jerseys had maximum yield at 61-63 months in 4th parity.
- Milking Shorthorns had maximum yield at 76-86 months in 6th parity.
Definition of Base Age

- Updating of age-season adjustments provided an opportunity to reconsider base age

- INTERBULL recommended adjustment to age of average production
  - Only USA, CAN, AUS, and ITA use mature age
  - ISR uses 36 months
  - Others use 24-30 months of age

- 37 months for Gue., Jer., and Hol.

- 42 months for Ayr., Br.Sw., and M.Sh.
Mature vs. Average Age Adjustment

**Mature age**
- traditional

**Average age**
- More realistic: puts record on scale of average cow in herd
- Adjusted and average yields similar for herds
- PTA closer to actual superiority (inferiority)
- Less bias when factors are not exact
Example 1

Holstein heifer: 20,000 lb. (305-2X) after calving at 20 months in August 1992 in Florida (region 5).

Old

Factor for region 5, 20 mo., Aug. = 1.44

Adjusted yield = 20,000 x 1.44 = 28,800

New

Factor for time 5, region 5, parity 1-Aug.,

20 mo. = 1.389

Adjusted yield = 20,000 x 1.389 = 27,780

Decrease = 1,020 lb.
Example 2

Holstein heifer: 20,000 lb. (305-2X) after calving at 20 months in January 1992 in Florida (region 5).

Old

Factor for region 5, 20 mo., Jan. = 1.33
Adjusted yield = 20,000 x 1.33 = 26,600

New

Factor for time 5, region 5, parity 1-Jan., 20 mo. = 1.350
Adjusted yield = 20,000 x 1.350 = 27,000

Increase = 400 lb.
Example 3

2 Holstein cows: 20,000 lb. (305-2X) after calving at 45 months in January 1992 in Florida (region 5).

- Cow A: 2nd calving, 120 days open parity 1
- Cow B: 3rd calving, 120 days open parity 2

-Old adjustment:
  Factor for region 5, 45 mo., Jan. = 1.05
  Adjusted yield = 20,000 x 1.05 = 21,000
Example 3 (cont.)

- New adjustment:

  **Cow A**
  - Factor for time 5, region 5, parity 2-Jan.,
  - 45 mo. = 1.038
  - Adjusted yield = 20,000 x 1.038 = 20,760

  **Cow B**
  - Factor for time 5, region 5, parity 3-Jan.,
  - 45 mo. = 1.015
  - Adjusted yield = 20,000 x 1.015 = 20,300

Difference of 460 lb. between cows A and B
Observations

- Former factors over-adjusted young cows, but the over-adjustment was less than had been anticipated when genetic trends were ignored.
- A combination of multiplicative and additive adjustment appears optimal.
- Effects of season have diminished.
- Adjustment for age within parity, not age alone, is necessary.
Where Do We Go from Here?

- Additive versus multiplicative adjustment
- Adjustment for current days open
- Impact of 3x milking
- Revisit the issue of base age
- Test day models for genetic evaluation
  - No longer need age adjustment for G. E.
  - Still needed for management and interpretation
## Effects of Previous Days Open on Holsteins in MI, OH, and IN from 1987 to 1992

<table>
<thead>
<tr>
<th>Days open</th>
<th>Milk (lb.)</th>
<th>Fat (lb.)</th>
<th>Protein (lb.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parity 2</td>
<td>Parity 3+</td>
<td>Parity 2</td>
</tr>
<tr>
<td>60</td>
<td>-863</td>
<td>-792</td>
<td>-28</td>
</tr>
<tr>
<td>100</td>
<td>-218</td>
<td>-184</td>
<td>-7</td>
</tr>
<tr>
<td>140</td>
<td>149</td>
<td>104</td>
<td>6</td>
</tr>
<tr>
<td>180</td>
<td>330</td>
<td>177</td>
<td>13</td>
</tr>
<tr>
<td>220</td>
<td>549</td>
<td>290</td>
<td>23</td>
</tr>
<tr>
<td>260</td>
<td>817</td>
<td>456</td>
<td>33</td>
</tr>
<tr>
<td>300</td>
<td>1134</td>
<td>673</td>
<td>44</td>
</tr>
</tbody>
</table>
Holstein Smoothed Parity-Age Factors
August Calving, Southeastern USA (Region 5)

1.4 Former milk factors
1964-68 milk factors 1987-92 milk factors

Calving age (months)

Factor

20 40 60 80

P1 P2 P3 P4 P5

Former milk factors
1964-68 milk factors
1987-92 milk factors
Holstein Smoothed Parity-Age Factors
January Calving, Wisconsin (Region 8)

1.4 Former milk factors
1987-92 milk factors

Calving age (months)

Factor

P1
P2
P3
P4
P5

Former milk factors
1987-92 milk factors
Holstein Smoothed Parity-Age Factors
August Calving, Wisconsin (Region 8)

1.4 Former milk factors
1987-92 milk factors

Factor

Calving age (months)

P1
P2
P3
P4
P5

Former milk factors
1987-92 milk factors
Jersey Parity-Age Factors
August Calving, Southeastern USA (Region 2)

1.4 Former milk factors
1987-92 milk factors
adjusted for previous and current days open

Calving age (months)

Factor

Former milk factors
1987-92 milk factors
adjusted for previous and current days open
Jersey Parity-Age Factors
August Calving, Southeastern USA (Region 2)

- Former milk factors (1987-92)
- 1987-92 milk factors adjusted for current days open only

Factors:
- P1
- P2
- P3
- P4
- P5

Calving age (months):
- 20
- 40
- 60
- 80
- 100
Jersey Parity-Age Factors
August Calving, Southeastern USA (Region 2)

1.4 Former fat-protein factors
1987-92 protein factors

1.2
1.1
1.0

40

1.5
60
80

P1

P2

P5

P3

P4

20

40

60

80

1.0

1.2

1.4

1.5

Factor

Calving age (months)

Former fat-protein factors
1987-92 fat factors
1987-92 protein factors