Different Selection Strategies for Improving Lactation Milk Yield and Persistency

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Modification of the Lactation Curve

- Genetic and/or environmental
- Redistribute the genetic gains between different stages of the lactation curve.
- Restricted index approach
- Conventional selection based on lactation EBV – The genetic curve is dictated by $G_{305 \times 305}$.

Simultaneous Selection for Lactation Milk and Persistency (Togashi and Lin, 2003)

- **Selection methods**
  - Index selection based on stage EBVs
  - Index selection based on RR coefficients
- Annual genetic gain assumed to be known
- Subjective redistribution of genetic gains between lactation stages

General Development of a Restricted Index for the Modification of the Lactation Curve

$$\mathrm{I} = \sum_{t=1}^{305} \mathrm{b}_{\mathrm{t}}\, \mathrm{EBV}_{t} = \hat{g}'b$$

$$\mathrm{H} = \sum_{t=1}^{305} g_{t} = g'\mathbf{1}$$

$$f = Var(I - H) + \lambda'(D'b - \theta k)$$

$$= b'Gb + \mathbf{1}'G\mathbf{1} - 2b'G\mathbf{1} + \lambda'(D'b - \theta k)$$

$$\begin{bmatrix} G & D & 0 \\ D' & 0 & -k \\ 0 & -k' & 0 \end{bmatrix} \begin{bmatrix} b \\ \lambda \\ \theta \end{bmatrix} = \begin{bmatrix} G\mathbf{1} \\ 0 \\ 0 \end{bmatrix}$$

Maximizing Lactation Milk Yield While Maintaining Constant Persistency (I_1)

- Persistency (P) = $\frac{EBV_{280}}{EBV_{60}}$

- Restriction: $\Delta G_{60} - \Delta G_{280} = 0$

- Let k=0 and $D = G_{60} - G_{280}$

$$\begin{bmatrix} G & G_{60} - G_{280} \\ G'_{60} - G'_{280} & 0 \end{bmatrix} \begin{bmatrix} b \\ \lambda \end{bmatrix} = \begin{bmatrix} G\mathbf{1} \\ 0 \end{bmatrix}$$

Maximizing Lactation Milk Yield While Holding the Peak Yield Constant (I_2)

- Restriction: $\Delta G_{60} = 0$
- Let $k = 0$ and $D = G_{60}$

$$\begin{bmatrix} G & G_{60} \\ G_{60}^{'} & 0 \end{bmatrix} \begin{bmatrix} b \\ \lambda \end{bmatrix} = \begin{bmatrix} G\mathbf{1} \\ 0 \end{bmatrix}$$

$$b = [I - G^{-1}G_{60}(G_{60}^{'}G^{-1}G_{60})^{-1}G_{60}^{'}]\mathbf{1}$$

Improvement of Lactation Milk Yield without Altering the Lactation Curve (I_d)

- Restriction: $\Delta G_1 = \Delta G_2 = \cdots = \Delta G_{305}$

  $\Delta G_1 : \Delta G_2 : \cdots : \Delta G_{305} = 1:1:\cdots:1$

- Let $k = \mathbf{1}$ and $D = G$

$$\begin{bmatrix} G & G & 0 \\ G' & 0 & -\mathbf{1} \\ 0 & -\mathbf{1}' & 0 \end{bmatrix} \begin{bmatrix} b \\ \lambda \\ \theta \end{bmatrix} = \begin{bmatrix} G\mathbf{1} \\ 0 \\ 0 \end{bmatrix}$$

$$b = \frac{\mathbf{1}'\mathbf{1}}{\mathbf{1}'G^{-1}\mathbf{1}} G^{-1}\mathbf{1} \implies b = G^{-1}1$$

Unweighted Linear Index (I_u)

$$I_u = EBV_L + \frac{EBV_{280}}{EBV_{60}}$$

$$= EBV_L + \left[\frac{\mu_{280}}{\mu_{60}} + \frac{1}{\mu_{60}} EBV_{280} - \frac{\mu_{280}}{\mu_{60}^2} EBV_{60} \right]$$

$$I_u = EBV_L + \frac{1}{\mu_{60}} EBV_{280} - \frac{\mu_{280}}{\mu_{60}^2} EBV_{60}$$

Weighted Linear Index (I_w)

$$I_w = \left(\frac{1}{\sigma_L}\right) EBV_L + \left(\frac{1}{\sigma_P}\right) \frac{EBV_{280}}{EBV_{60}}$$

$$\sigma_L \sigma_P I_w = \sigma_P\, EBV_L + \sigma_L\, \frac{EBV_{280}}{EBV_{60}}$$

$$I_w = \sigma_P EBV_L + \sigma_L \left(\frac{1}{\mu_{60}} EBV_{280} - \frac{\mu_{280}}{\mu_{60}^2} EBV_{60}\right)$$

Six Selection Strategies Compared

1) $EBV_L = \sum_{t=1}^{305} EBV_t$

2) I_1 : $\Delta G_{60} - \Delta G_{280} = 0$

3) I_2 : $\Delta G_{60} = 0$

4) I_d : $\Delta G_1 = \Delta G_2 = \cdots = \Delta G_{305}$

5) $I_u = EBV_L + \frac{EBV_{280}}{EBV_{60}}$

6) $I_w = \left(\frac{1}{\sigma_L}\right) EBV_L + \left(\frac{1}{\sigma_P}\right) \frac{EBV_{280}}{EBV_{60}}$

Evaluation of Genetic Improvement in Persistency

- Rate of decline: $\beta = \dfrac{\Delta G_{60} - \Delta G_{280}}{220}$
  - β > 0: Persistency deteriorates.
  - β < 0: Persistency improves.
  - β = 0: No change in persistency
- $G_{335x335}$ (Pool et al., 2000) → $G_{305x305}$

Table 1. Genetic responses in lactation EBV, persistency and the rate of decline (β)

Selection strategies	ΔEBV_L	ΔG_{60}	ΔG_{280}	β
EBV_L	672	2.28	2.04	1.06
$I_1(\Delta G_{60}=\Delta G_{280})$	669	2.21	2.21	0
$I_2\ (\Delta G_{60}=0)$	120	0	1.25	-5.69
$I_d\ (\Delta G_1 = \Delta G_2 = \cdots = \Delta G_{305})$	560	1.86	1.86	0
I_u	672	2.28	2.04	1.06
I_w	509	1.28	2.23	-4.34

Conclusions

- General formula: a useful tool for modifying the shape of lactation curve
- Lactation EBV: the greatest response in lactation milk coupled with the worst persistency
- I_2 ($\Delta G_{60}=0$): the greatest persistency but the least gain in milk.
- I_1($\Delta G_{60}=\Delta G_{280}$): the method of choice for improving lactation milk without decreasing persistency.
- I_W : a viable strategy for simultaneous improvement