Improving carcass traits by selection in five beef cattle breeds

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Study objective

Why to improve carcass composition?
- Effective production of animal protein for human consumption
- Control of carcass quality

Main beef breeds in Finland
British breeds: Hereford, Aberdeen Angus
Swiss breed: Simmental
French breeds: Charolais, Limousin

Objectives
1) Estimate heritabilities and genetic correlations for carcass weight, carcass conformation and carcass fat for five main breeds

2) Compare alternative selection scenarios to quantify the way genetic correlations constrain breeding of the three traits
Carcass weight, conformation and fat recorded in five slaughter houses

Carcass conformation and fat recorded with EUROP scoring:
• Conformation (1-15): 1 = poor and 15 = extensive musculature
• Fat (1-5): 1 = low fat and 5 = extensive fat

**Breeding objective:** Increase weight and conformation, avoid extensive fat

<table>
<thead>
<tr>
<th>Breed</th>
<th>Phenotyped animals</th>
<th>n offspring per bull (mean; range)</th>
<th>n herds per bull (mean; range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hereford</td>
<td>19539</td>
<td>14.1 (1-181)</td>
<td>2.8 (1-50)</td>
</tr>
<tr>
<td>Ab. Angus</td>
<td>13598</td>
<td>13.3 (1-99)</td>
<td>2.9 (1-55)</td>
</tr>
<tr>
<td>Simmental</td>
<td>6879</td>
<td>12.4 (1-151)</td>
<td>2.7 (1-34)</td>
</tr>
<tr>
<td>Charolais</td>
<td>13611</td>
<td>13.3 (1-134)</td>
<td>2.7 (1-45)</td>
</tr>
<tr>
<td>Limousin</td>
<td>15072</td>
<td>14.8 (1-290)</td>
<td>2.6 (1-50)</td>
</tr>
</tbody>
</table>

+ pedigree back to 60’s
For carcass weight, conformation and fat:

**Random effects**
- Animal$_j$ random genetic effect of an animal $j$ ($j = 1$-nro of animals)
- Error$_{ijklmn}$ random residual term

**Fixed effects**
- HerdYear$_k$ herd-year interaction ($k = 1$-number of combinations)
- DamAge$_l$ age class of a dam of an individual $j$ ($l = 1$-7)
- BirthSeason$_m$ season of the birth date ($m = 1$-5)
- Twin$_n$ twin or as a singleton birth ($n = 1$-2)
- Gender$_o$ gender ($o = 1$-2)
- $b_{\text{Age1}(\text{Gender})}$ linear regression coefficient of age for each gender
- $b_{\text{Age2}(\text{Gender})}$ quadratic regression coefficient of age for each gender
Trait means

- **High carcass weight**
  - Carcass weight (kg)
  - Hereford
  - Angus
  - Simmental
  - Charolais
  - Limousin

- **High muscularity**
  - Carcass conformation (score)
  - Hereford
  - Angus
  - Simmental
  - Charolais
  - Limousin

- **Low fat**
  - Carcass fat (score)
  - Hereford
  - Angus
  - Simmental
  - Charolais
  - Limousin
Trait heritability

Our data, average $h^2$ of 0.43 (weight), 0.34 (conformation), and 0.33 (fat)

In literature, average $h^2$ of 0.31, 0.23, and 0.21

(Pattern the same, overall level higher in our data)

Trait correlations

High weight – High muscularity
Favourable for all breeds
Trait correlations

High weight – High fat
Unfavourable especially in British breeds

Carcass weight vs. fat

Correlation coefficient

Hereford
Angus
Simmental
Charolais
Limousin
More favourable in French breeds (High muscularity and Low fat - relationship)
Breed differences

In large body-sized beef, favourable 'high conformation-low fat' relationship

In dairy, unfavourable 'high conformation-high fat' relationship

Selection response: Selection for weight

Consistent increase in weight and conformation (modest)

Index theory calculations for genetic gain (Hazel 1943)

Mass selection with intensity = 0.5

Economic values used:

\[ a_{\text{Weight}} = 1 \, \text{€} \]
\[ a_{\text{Conformation}} = 0 \, \text{€} \]
\[ a_{\text{Fat}} = 0 \, \text{€} \]
Selection response: Economic values

Index theory calculations for genetic gain (Hazel 1943)

Mass selection with intensity = 0.5

Economic values used for Irish production system (Amer et al. 2001; Evans et al. 2012)

\[ a_{\text{Weight}} = 2.95 \, \text{€} \]
\[ a_{\text{Conformation}} = 14.77 \, \text{€} \]
\[ a_{\text{Fat}} = -7.86 \, \text{€} \]

Breed-specific responses with carcass fat decreasing in continental breeds
Conclusions

Genetic variation exists for carcass weight, carcass conformation and carcass fat

Simultaneous improvement of carcass weight and conformation easy in all breeds

For fat, unfavourable correlation with carcass weight especially in Hereford (British breed)

Breed difference - Correlations of fat more favourable in large-body sized and muscular continental breeds