Genetic correlations among fighting ability, fertility & productive traits in Valdostana cattle

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Introduction

- Aosta Chestnut & Black Pied cattle -> Autochthonous of West Alps
- Strong attitude to fight -> “Batailles de Reines”
- Fighting ability -> Capability to win a contest (Parker, 1974)

*Batailles de Reines*

- 20 heats + final fight
- Knock-out battles among pairs of cows, by weight categories
- Check for milking & pregnancy to participate
Selection in Valdostana cattle

- From 2012 fighting ability included in an aggregate selection index
- Fighting ability from “Batailles de Reines” cow performances

Best fighters are supposed to present
- A more “masculine” phenotype
- Lower milk production

Fighting ability & milk yield/fertility expected to be antagonistic traits
Aim of the study

Genetic correlations of fighting ability with milk yield, linear type traits & fertility

Trends of breeding values for all studied traits
Materials & Methods

Herd-book information for Aosta Chestnut and Aosta black pied breeds (Updated at November 2012)

Genetic evaluation of fighting ability, linear type traits, milk yield, fertility:

- Single trait linear models for variance components & heritability
- Bi-trait linear models for genetic correlations
- Genetic trends of estimated breeding values

EM-REML method, REMLF90 software (Misztal, 2008)
Traits: 1. Fighting ability

Evaluation based on a Placement score obtained from results of fighting (i.e., wins achieved, no. of participant at tournament and type of tournament; Heat of final; Sartori & Mantovani, 2010)

Placement Score (PS)

\[ PS_{ijkl} = 20 + ty_i + d_j + 2w_k \]

34,190 records; 10,735 cows; 21,198 animals in pedigree

Model:

\[ Y_{ijklmno} = \mu + YB_i * C_j + HR_k + AC_l + bW*C_j + Pe_m + a_n + e_{ijklmno} \]

Year-Battle-Category (756 levels), Herd-Round (4,771 levels), Age (7 classes), Weight within Category, Permanent environmental effect (10,735 cows) and additive Animal effect (21,198 animals in pedigree)
Traits: 2. linear type

- Yearly scores of type traits on primiparous cows (aged ~ 3 years) by trained classifiers
- Use a selection of traits from Fleshiness, Size, Thinness & Udder
- Continuous (1-5) point scale

19,292 records; 19,292 cows; 31,700 animals in pedigree

Model:

\[ y_{ijklm} = \mu + HRC_i + APc_j + DIMc_k + a_l + e_{ijklm} \]

Herd-Round-Classifier (5,400 levels), Age at first parity (9 classes)
Days in milk (7 classes) and additive Animal effect (31,700 animals in pedigree)
Traits: 3. Milk, Fat & Protein

- Individual production of milk, fat & protein in the whole lactation
- From National official milk recording system

25,107 records; 10,509 cows; 22,505 animals in pedigree

Model:

\[ y_{ijklmn} = \mu + HY_i + CalvSeas_j + CC_k + nLact_l + Pe_m + a_n + e_{ijklmn} \]

Herd-year calving (4,662 levels), Calving season (5 classes), Calving-conception interval (16 classes), number of lactation (5 levels), Permanent environmental effect (10,509 cows), and additive Animal genetic effect (22,505 animals in pedigree)
Traits: 4. Fertility

- Parity-Conception interval (PC)
- Calving interval (CI; from parity to parity)
- Italian official milk recording system

18,157 records; 6,214 cows; 15,640 animals in pedigree

Model:

\[ y_{ijklmn} = \mu + H_Y_i + CalvSeas_j + nLact_k + Pe_l + a_m + e_{ijklmn} \]

Herd-year calving (3,486 levels), Calving season (5 classes), number of lactation (5 levels), Permanent environmental effect (6,214 cows), and additive Animal genetic effect (15,640 animals in pedigree)
Genetic correlation analysis

Rec.: 29,954  
Cows: 12,686  
Pedig.: 23,746

Rec.: 47,014  
Cows: 7,926  
Pedig.: 16,968

Rec.: 40,144  
Cows: 6,380  
Pedig.: 16,022

\[
\begin{bmatrix}
    a_1 \\
    a_2 \\
    p_1 \\
    p_2 \\
    e_1 \\
    e_2
\end{bmatrix}
\begin{bmatrix}
    A\sigma_{a1}^2 & A\sigma_{a1a2} & 0 & 0 & 0 & 0 \\
    A\sigma_{a1a2} & A\sigma_{a2}^2 & 0 & 0 & 0 & 0 \\
    0 & 0 & A\sigma_{p1}^2 & 0 & 0 & 0 \\
    0 & 0 & 0 & A\sigma_{p2}^2 & 0 & 0 \\
    0 & 0 & 0 & 0 & I\sigma_{e1}^2 & 0 \\
    0 & 0 & 0 & 0 & 0 & I\sigma_{e2}^2
\end{bmatrix}
\]
## Heritability

<table>
<thead>
<tr>
<th>Trait</th>
<th>$\sigma^2_{pe}$</th>
<th>$\sigma^2_a$</th>
<th>$\sigma^2_r$</th>
<th>$h^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fighting ability</td>
<td>0.984</td>
<td>0.604</td>
<td>5.871</td>
<td>0.081</td>
</tr>
<tr>
<td>Parity-Conception (PC)</td>
<td>0.340</td>
<td>0.251</td>
<td>10.42</td>
<td>0.022</td>
</tr>
<tr>
<td>Calving Interval (CI)</td>
<td>0.357</td>
<td>0.256</td>
<td>10.49</td>
<td>0.023</td>
</tr>
<tr>
<td>Milk</td>
<td>0.116</td>
<td>0.116</td>
<td>0.156</td>
<td>0.299</td>
</tr>
<tr>
<td>Fat</td>
<td>0.014</td>
<td>0.015</td>
<td>0.025</td>
<td>0.271</td>
</tr>
<tr>
<td>Protein</td>
<td>0.012</td>
<td>0.012</td>
<td>0.018</td>
<td>0.285</td>
</tr>
<tr>
<td>Fleshiness</td>
<td>-</td>
<td>0.070</td>
<td>0.392</td>
<td>0.152</td>
</tr>
<tr>
<td>Front muscularity</td>
<td>-</td>
<td>0.058</td>
<td>0.456</td>
<td>0.113</td>
</tr>
<tr>
<td>Thigh and Buttocks rear view</td>
<td>-</td>
<td>0.031</td>
<td>0.332</td>
<td>0.084</td>
</tr>
<tr>
<td>Thorax depth</td>
<td>-</td>
<td>0.075</td>
<td>0.351</td>
<td>0.176</td>
</tr>
<tr>
<td>Thinness</td>
<td>-</td>
<td>0.023</td>
<td>0.534</td>
<td>0.041</td>
</tr>
<tr>
<td>Udder</td>
<td>-</td>
<td>0.063</td>
<td>0.416</td>
<td>0.132</td>
</tr>
<tr>
<td>Fore udder attach</td>
<td>-</td>
<td>0.087</td>
<td>0.540</td>
<td>0.138</td>
</tr>
<tr>
<td>Rear udder attach</td>
<td>-</td>
<td>0.065</td>
<td>0.428</td>
<td>0.132</td>
</tr>
<tr>
<td>Udder width</td>
<td>-</td>
<td>0.082</td>
<td>0.467</td>
<td>0.150</td>
</tr>
</tbody>
</table>
## Correlations of fertility vs. milk

<table>
<thead>
<tr>
<th></th>
<th>PC</th>
<th>CI</th>
<th>Milk</th>
<th>Fat</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>0.022</td>
<td><strong>0.999</strong></td>
<td>-0.297</td>
<td>-0.301</td>
<td>-0.321</td>
</tr>
<tr>
<td>CI</td>
<td><strong>0.999</strong></td>
<td>0.023</td>
<td>-0.325</td>
<td>-0.355</td>
<td>-0.357</td>
</tr>
<tr>
<td>Milk</td>
<td>0.640</td>
<td>0.532</td>
<td><strong>0.872</strong></td>
<td><strong>0.949</strong></td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>0.666</td>
<td>0.586</td>
<td>0.954</td>
<td>0.271</td>
<td><strong>0.903</strong></td>
</tr>
<tr>
<td>Protein</td>
<td>0.632</td>
<td>0.571</td>
<td>0.979</td>
<td>0.965</td>
<td>0.285</td>
</tr>
</tbody>
</table>

**Phenotypic correlations**

**Genetic correlations**

PC = Parity-conception interval; CI = Calving interval; Milk, Fat & Protein = Whole lactation, kg
## Correlations Fighting vs. others

<table>
<thead>
<tr>
<th>Fighting ability</th>
<th>$\sigma_{Pe1Pe2}$</th>
<th>$r_{Pe}$</th>
<th>$\sigma_{g1g2}$</th>
<th>$r_g$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parity-Conception (months)</td>
<td>0.236</td>
<td>0.378</td>
<td>0.129</td>
<td>0.361</td>
</tr>
<tr>
<td>Calving Interval (months)</td>
<td>0.251</td>
<td>0.393</td>
<td>0.109</td>
<td>0.304</td>
</tr>
<tr>
<td>Milk yield (Kg)</td>
<td>0.139</td>
<td>0.037</td>
<td>-0.599</td>
<td>-0.221</td>
</tr>
<tr>
<td>Fat yield (Kg)</td>
<td>0.077</td>
<td>0.058</td>
<td>-0.267</td>
<td>-0.284</td>
</tr>
<tr>
<td>Protein yield (Kg)</td>
<td>0.128</td>
<td>0.104</td>
<td>-0.284</td>
<td>-0.333</td>
</tr>
<tr>
<td>Fleshiness</td>
<td>-</td>
<td>-</td>
<td>-0.007</td>
<td>-0.030</td>
</tr>
<tr>
<td>Front muscularity</td>
<td>-</td>
<td>-</td>
<td>0.020</td>
<td>0.092</td>
</tr>
<tr>
<td>Thigh and Buttocks rear view</td>
<td>-</td>
<td>-</td>
<td>-0.020</td>
<td>-0.084</td>
</tr>
<tr>
<td>Thorax depth</td>
<td>-</td>
<td>-</td>
<td>0.033</td>
<td>0.149</td>
</tr>
<tr>
<td>Thinness</td>
<td>-</td>
<td>-</td>
<td>-0.022</td>
<td>-0.128</td>
</tr>
<tr>
<td>Udder</td>
<td>-</td>
<td>-</td>
<td>-0.032</td>
<td>-0.146</td>
</tr>
<tr>
<td>Fore udder attach</td>
<td>-</td>
<td>-</td>
<td>0.017</td>
<td>0.062</td>
</tr>
<tr>
<td>Rear udder attach</td>
<td>-</td>
<td>-</td>
<td>-0.056</td>
<td>-0.250</td>
</tr>
<tr>
<td>Udder width</td>
<td>-</td>
<td>-</td>
<td>-0.065</td>
<td>-0.265</td>
</tr>
</tbody>
</table>
Genetic trend for fighting ability
Genetic trend for milk yield
Genetic trend for fertility traits

EBV (mo.)


Birth year

Parity conception Int.  Calving interval
Genetic trend for fleshiness traits

![Genetic trend for fleshiness traits graph]

- **EBV (pt.s)**
- **Birth year**

- **Fleshiness**
- **Front musculature**
- **Thigh & Buttocks rear view**
Genetic trend for udder traits

EBV (pt.s)

Birth year


-0.06 -0.04 -0.02 0.00 0.02 0.04 0.06 0.08

Udder Fore udder attach Rear udder attach Udder width
Genetic trend for main traits

EBV (std. units)

Birth year


Fighting Ability  Milk  Calving Interval  Fleshiness  Udder
Conclusions

- Genetic correlations of fighting ability:
  - Moderate and negative ($r_g = -0.28 \pm 0.06$) with milk traits
  - Moderate and positive ($r_g = 0.33 \pm 0.04$) with fertility traits
  - Low positive with “masculine traits” (front musculature, $r_g = 0.09$; thorax depth, $r_g = 0.15$) and low/moderate negative with “feminine traits” (udder, $r_g = -0.15$; rear udder attack, $r_g = -0.25$; udder width, $r_g = -0.27$)

- Positive trends for fighting and musculature, slightly positive for fertility traits and steady for milk and udder traits:

  Aosta Chestnut and Aosta Black Pied are becoming more and more “good fighters”, and less “milk producers”
Thank you for your attention!!!

INFO: cristina.sartori@unipd.it
## Correlations among linear type traits

<table>
<thead>
<tr>
<th></th>
<th>FL</th>
<th>FrM</th>
<th>T&amp;B</th>
<th>Td</th>
<th>Th</th>
<th>Ud</th>
<th>FU</th>
<th>RU</th>
<th>UW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fleshiness (FI)</td>
<td>0.15</td>
<td>0.93</td>
<td>0.96</td>
<td>0.62</td>
<td>-0.08</td>
<td>-0.35</td>
<td>-0.34</td>
<td>-0.28</td>
<td>-0.33</td>
</tr>
<tr>
<td>Front Muscul. (FrM)</td>
<td>0.72</td>
<td>0.11</td>
<td>0.88</td>
<td>0.76</td>
<td>0.01</td>
<td>-0.39</td>
<td>-0.37</td>
<td>-0.33</td>
<td>-0.37</td>
</tr>
<tr>
<td>Thigh and Buttocks (T&amp;B)</td>
<td>0.74</td>
<td>0.56</td>
<td>0.08</td>
<td>0.50</td>
<td>-0.07</td>
<td>-0.26</td>
<td>-0.26</td>
<td>-0.24</td>
<td>-0.29</td>
</tr>
<tr>
<td>Thorax depth (Td)</td>
<td>0.43</td>
<td>0.43</td>
<td>0.37</td>
<td>0.18</td>
<td>0.11</td>
<td>-0.01</td>
<td>-0.20</td>
<td>-0.02</td>
<td>-0.12</td>
</tr>
<tr>
<td>Thinness (Th)</td>
<td>0.01</td>
<td>0.01</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.04</td>
<td>0.11</td>
<td>0.40</td>
<td>0.39</td>
<td>0.42</td>
</tr>
<tr>
<td>Udder (Ud)</td>
<td>-0.09</td>
<td>-0.07</td>
<td>-0.05</td>
<td>-0.17</td>
<td>0.48</td>
<td>0.13</td>
<td>0.87</td>
<td>0.86</td>
<td>0.89</td>
</tr>
<tr>
<td>Fore udder attach (FU)</td>
<td>-0.03</td>
<td>-0.02</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.10</td>
<td>0.58</td>
<td>0.14</td>
<td>0.65</td>
<td>0.69</td>
</tr>
<tr>
<td>Rear udder attach (RU)</td>
<td>-0.08</td>
<td>-0.06</td>
<td>-0.04</td>
<td>0.01</td>
<td>0.10</td>
<td>0.59</td>
<td>0.4</td>
<td>0.13</td>
<td>0.96</td>
</tr>
<tr>
<td>Udder width (UW)</td>
<td>-0.07</td>
<td>-0.05</td>
<td>-0.03</td>
<td>0.01</td>
<td>0.10</td>
<td>0.57</td>
<td>0.37</td>
<td>0.59</td>
<td>0.15</td>
</tr>
</tbody>
</table>

**Genetic correlations**

**Phenotypic correlations**