Opportunities and obstacles of the use of genomic data in sheep breeding – large versus small populations –

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Croatia vs. France

• Inferiority complex of small country?
  – Sport (FIFA Football World Cup)

  – Breeding
    • No competition
Aim

• To draw the benefit and obstacles of using genomic data in sheep through contrasting situations
  – Large vs. Small: France vs. Croatia

• Sheep breeds: large vs. smaller populations
  – French (Lacaune, Red-Faced Manech, Black-Faced Manech, Basco-Béarnaise, Corse)
  – Croatian (Istrian, Pag)
Dairy sheep in France
3 traditional areas of production / 5 breeds

- Selection since 70’s
- 500,000 AI per year

**Western Pyrenean area**
- 470,000 ewes
- 120,000 in selection
- 250 new AI rams each year

3 breeds: Red-faced Manech, Black-faced Manech, Basco-Béarnaise

**Roquefort area**
- 800,000 ewes
- 200,000 in selection
- 300 new AI rams each year

**Corsica island**
- 85,000 ewes
- 18,000 in selection
- 20 new AI rams each year

Lacaune

Corse
Breeding programs

• Dairy sheep breeding programs switched towards genomic selection – 2015 (Lacaune) - 2017 (Pyrenean breeds) - 2020 (Corse)

Start of genomic selection (GS)
(use of ssGBLUP evaluation for early genomic pre-selection)

• Genomic evaluation: different reference population sizes across breed

<table>
<thead>
<tr>
<th>Breed</th>
<th>Genotyped rams</th>
<th>Genotyped AI rams with daughters</th>
<th>Rams genotyped yearly (2023)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lacaune</td>
<td>32 K</td>
<td>7 K (since 1996)</td>
<td>~3500</td>
</tr>
<tr>
<td>Red-Faced Manech</td>
<td>7 K</td>
<td>3.3 K (since 1998)</td>
<td>~700</td>
</tr>
<tr>
<td>Black-Faced Manech</td>
<td>1.3 K</td>
<td>0.7 K (since 1996)</td>
<td>~100</td>
</tr>
<tr>
<td>Basco-Béarnaise</td>
<td>2.4 K</td>
<td>1.1 K (since 1999)</td>
<td>~250</td>
</tr>
<tr>
<td>Corse</td>
<td>25 K</td>
<td>0.4 K (since 2003)</td>
<td>~350</td>
</tr>
</tbody>
</table>
Benefits of genomic selection

- Generating an annual genetic gain for economical index ranging from 0.12 to 0.35 genetic standard deviation
- Increase in genetic gain from 16 to 57%
Multiple purpose of genotyping

• Cost of genotypings in sheep: higher than in cattle when compared to the animal value

• => Multi-purpose valorisation of the genotypings
  – Genomic selection (through genomic evaluation)
  – Major genes
    • PRP – scrapie resistance
    • SOCS2 – susceptibility to Somatic Cells
    • Horn – management of horn in Red-faced Manech
    • New genes in the next years – lethal mutations, cryptorchidism
  – Parentage verification and discovery
Parentage verification and discovery

- Parentage verification followed by parentage discovery applied on males chosen for genomic selection (before genomic pre-selection)

<table>
<thead>
<tr>
<th>Breed</th>
<th>Percentage of wrong sire</th>
<th>Percentage of sire discovery when wrong sire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lacaune</td>
<td>4.6</td>
<td>92</td>
</tr>
<tr>
<td>Pyrenean breeds</td>
<td>4.4</td>
<td>87</td>
</tr>
</tbody>
</table>

- Sire discovery on ewes in flocks that does not do AI (including organic farms where synchronisation by hormone is forbidden)

<table>
<thead>
<tr>
<th>Breed</th>
<th>Number of females submitted to sire discovery in 2023</th>
<th>Percentage of sire assignation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lacaune</td>
<td>1,483</td>
<td>95</td>
</tr>
<tr>
<td>Pyrenean breeds</td>
<td>2,091</td>
<td>95</td>
</tr>
</tbody>
</table>
Dairy sheep in Croatia: traditional production area - Mediterranean area (islands, coasts of the Adriatic Sea and Dalmatian hinterland)

2 breeds under selection

**Istria**
- ~13,800 ewes
- Breeding and selection
  - 1,026 ewes and 35 rams, 12 flocks
  - Dual purpose (dairy & meat)
  - Native mating

**Pag island**
- ~30,000 ewes
- Breeding and selection
  - 4,086 ewes and 78 rams, 34 flocks
  - Dairy orientated
  - Native mating, harsh environment, (“BURA” > 200 km/h), exotic aromatic plants, forage enriched with sea salt
Breeding program

- Milk recording (ICAR)
- Dairy traits (milk, fat, protein, SCC)
- Aim → to increase milk yield

- Pedigree and dairy records
- Pedigree BLUP →

\[
\begin{align*}
\mathbf{b} &= \begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + A^{-1}\lambda \end{bmatrix}^{-1} \begin{bmatrix} X'y \\ Z'y \end{bmatrix} \\
\mathbf{a} &= \begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + A^{-1}\lambda \end{bmatrix}^{-1} \begin{bmatrix} X'y \\ Z'y \end{bmatrix}
\end{align*}
\]

Numerator relationship matrix
BLUP issues

Disconnected flocks !!!!

BLUP

The issue of disconnectedness:

- Neglected in some breeding programs. BLUP is not MAGIC!!!
- Impossible to disentangle genetic from environmental effects
- Small ruminants and beef cattle NO/limited use of AI
Future genetic improvement

• Goal
  – Dairy performance improvement via selection
    • Important for long term productive and economic viability
  – Maintenance of the existing genetic variability
    • Vital for their resilience in unpredictable future environment

• Implementation of the basic principles of genomic optimum contribution selection (OCS) in existing breeding program
  – To provide selection progress on targeted trait/s with minimal loss of genetic variability (ultimate goal of project OPTI SHEEP, CSF, IP: 2019-04-3559)
Genotyping – as a first step

• Genotyping with the OvineSNP50 chip - Weatherbys Ireland
  – Funds for genotyping: Project OPTI-SHEEP (CSF - IP-2019-04-3559), Submeasure 10.2., Breeding Association of Sheep and Goats

• Genotypes (N=3,976)
  – Istrian – 1,293 (1,207 ewes, 86 rams)
  – Pag – 2,683 (2,543 ewes, 140 rams)

• Almost the whole breeding population of Istrian and Pag was genotyped
OCS implementation

• Transition from pedigree based BLUP to single-step GBLUP
• Development of pipelines for routine genomic OCS - in progress
• **BLUPF90** a family of programs
  – RENUMF90, AIREMLF90, BLUPF90
• Pedigree additive relationship combined with genomic information (following the theory of ssGBLUP)
  – Numerator relationship matrix $A^{-1}$ was replaced by matrix $H^{-1}$
However

• Many practical and scientific questions
• Estimation of specific genetic parameters
  – Linkage disequilibrium
  – Genomic inbreeding
  – Genetic connectedness between flocks
• How to optimize selection with maintenance of genetic diversity, the results could also be beneficial to other sheep and livestock breeding programs
ESTIMATION OF GENETIC CONNECTEDNESS BETWEEN FLOCKS IN POPULATION OF ISTRIAN SHEEP

A Koseja, J Ranjšek, A Kazaj, M Spalari, M Spalari, J Ranjšek

International initiative

• Across country evaluation in some multi-country breeds
  – Case of ARDI project between French Manech et Spanish Latxa (dairy sheep)
  – Interest in goats for Saanen or Alpine
  – Lacaune in Croatia – increasing population – inclusion either in French or international evaluation

• Share of genotypings / panel of SNPs
  – For parentage verification or genomic selection

• Share expertise across breeds of sheep and goat

European Reference Centre could serve this idea to better exchange in small ruminant (not only on phenotyping as it is the case in the SGC WG, but also on genetic evaluation, valorisation of genotypings)
Thank you for the attention!