New breeding goals and role of genomics on adaptation and resilience traits: the case study of French dairy sheep

Jean-Michel ASTRUC,
Diane BUISSON, Hélène LARROQUE, Gilles LAGRIFFOUL

EAAP Annual Meeting 2018 Dubrovnik (Croatia)
Session 65: Practices and prospects for adapting to a challenging Mediterranean environment
30 Aug. 2018
Outline

Dairy sheep in France and overview on breeding programs

Development of genomic selection in French dairy sheep

Novel traits recently taken into account or under study

In which way the situation is favorable for adaptation and resilience?
1.4 M dairy sheep in France (27% of sheep population)

- Local breeds raised in their own areas (mostly harsh & mountainous) & production systems.
- Production of PDO cheese only with milk from local breed.

Western Pyrenees
- 34% ewes
  - Black-faced & Red-faced Manech, Basco-Béarnaise

Roquefort area
- 56% ewes

Corsica Island
- 6% ewes
  - Lacaune

Corse
Breeding programs: main features and current situation

- Based on:
  - *Pyramidal organization* within each breed for benefit to the whole population (organize both creation and diffusion)

<table>
<thead>
<tr>
<th>Breed</th>
<th>% of ewes in selection programs for each breed</th>
<th>% AI in selection flocks</th>
<th># Progeny-tested rams</th>
<th>Annual Genetic gain ($\sigma_g$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lacaune</td>
<td>178,000</td>
<td>85%</td>
<td>445</td>
<td>0.23</td>
</tr>
<tr>
<td>Basco-B.</td>
<td>25,000</td>
<td>50%</td>
<td>44</td>
<td>0.16</td>
</tr>
<tr>
<td>BF Manech</td>
<td>11,000</td>
<td>45%</td>
<td>26</td>
<td>0.11</td>
</tr>
<tr>
<td>RF Manech</td>
<td>83,000</td>
<td>50%</td>
<td>146</td>
<td>0.17</td>
</tr>
<tr>
<td>Corse</td>
<td>17,000</td>
<td>36%</td>
<td>25</td>
<td>0.10</td>
</tr>
</tbody>
</table>

20% = technical-economic optimum
Breeding programs: different ways to valorize the genetic gain

Different ways according to the industry situation in each production areas

RED-FACED MANECH

Milk yield (liters)

LACAUNE

Milk yield (liters)

MY  EBVs  Flock x yr effect
Breeding programs in France: breeding goals from start to 2018

Lacaune breed

Pyrenean breeds

Corse breed

Milk YIELD (MY)

MY + QUALITY

MY + QUALITY + FUNCTIONAL

1985

2000

2005

2016

Milk Yield (MY)

MY + Quality

MY + Quality + Functional

Udder morphology

MY

SCS

F% & P%
The strengths of the classical breeding programs regarding adaptation and resilience traits

- **On-farm selection** => phenotypes expressed within the constraints of the local system & environment

- **Local breeds**
  - Well adapted to local production systems / pedoclimatic conditions
  - Maintain local breeds = *maintain genetic diversity*

- **Maintain genetic variability within breed** (through balanced selection objectives + management of genetic variability + high number of reproducers) => allows adaptation to upcoming changes

- **GxE?** Might be limited as rams used (by AI) in wide range of systems
**Genomic selection: new opportunities?**

2009: availability of OvineSNP50 BeadChip + start of GS in dairy cattle

=> A raising interest in French dairy sheep

**Sheep vs dairy cattle: less favorable situation**

- Lesser reference population + less precise phenotypes + lesser LD
  - Lesser accuracy
- Cost of genotypes / gross margin higher
  - Lesser selection intensity
- Rams progeny-tested at 3 yr-old
  - Fewer gain on generation interval

=> Lesser expected increase of genetic gain

2009-2016 in France: 7 years of R&D programs to assess genomic selection in dairy sheep
Genomic selection: reference populations

<table>
<thead>
<tr>
<th>Situation in 2018</th>
<th>Genotyped rams</th>
<th>With daughters</th>
<th>Reference population depth</th>
<th>1er complete year of birth</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Manech</td>
<td>3007</td>
<td>2238</td>
<td>1998-2017</td>
<td>2000</td>
</tr>
<tr>
<td>Basco-Béarnaise</td>
<td>945</td>
<td>667</td>
<td>1999-2017</td>
<td>1999</td>
</tr>
<tr>
<td>Corse</td>
<td>746</td>
<td>243</td>
<td>2001-2017</td>
<td>2005</td>
</tr>
</tbody>
</table>
Genomic selection: genomic evaluation

Single-Step GBLUP

Gain in accuracy - GEBV vs PA

Sources:
Baloche et al, 2014 ;
Astruc et al, 2016
Genomic selection: genomic breeding programs

Selection on PA + PrP genotypes of lambs before progeny-test

- Progeny test
- Lay off
- Diffusion
- Sires

Selection on PA + PrP genotypes of lambs before genotyping

- Genotyping of lambs (3-month old)
- Ref Pop maintaining - 75%
- Genomic sires
- Diffusion - 20%
- Sires

Expected ΔG: + 10-20% (if pre-GS 1/3)
Low extra cost for breeding organizations
Genomic selection: first results observed in Lacaune breed

- Shift to GS in Lacaune breed in 2015
- Shift to GS in Pyrenean breeds in 2017
- Shift to pseudo-GS in Corse breed in 2016

Effect of genomic selection: +17%
Genomic selection: how to benefit from the extra genetic gain

- Apply a higher selection pressure on current selected traits

- Select for new traits => more balanced selection objectives (eg. adaptation & resilience)
  - challenge = phenotype new traits
    ⇒ WARNING: extra cost for the program
    ⇒ Best if covered by the entire value chain of the industry

- Better manage genetic variability with genomic tools
# New traits under study or already accounted for

<table>
<thead>
<tr>
<th>Main goal</th>
<th>Traits</th>
<th>Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rusticity/robustness/health/resilience</td>
<td>Functional longevity</td>
<td>R&amp;D programs Experimental EBVs</td>
</tr>
<tr>
<td></td>
<td>Milk persistency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resistance to internal parasites</td>
<td>EBVs available ≥ 2015 in Pyr. breeds</td>
</tr>
<tr>
<td></td>
<td>Udder health</td>
<td>SCC in breeding goals R&amp;D on genetic x milking routine x machine x drying-off treatment</td>
</tr>
<tr>
<td>Milk quality/cheese-making traits</td>
<td>Fine milk composition</td>
<td>Mid InfraRed Spectrometry</td>
</tr>
<tr>
<td>Reproduction/Rams (efficiency of GS)</td>
<td>Semen production</td>
<td>EBVs available ≥ 2013 in all breeds</td>
</tr>
<tr>
<td></td>
<td>Functional morphology of rams</td>
<td>EBVs available ≥ 2017 in Lacaune</td>
</tr>
<tr>
<td></td>
<td>Form of the horns</td>
<td>EBVs available ≥ 2016 in Corse</td>
</tr>
</tbody>
</table>
New traits under study: functional longevity

- Ability to delay culling for reasons not linked to the level of production
  - Synthetic trait
  - But
    - Quite low heritability (survival analysis => h2 ~ 10%)
    - Rams are known lately (GS maybe useful)

- How to benefit from a higher genetic level on functional longevity
  - Lower replacement rate
  - Higher selection pressure on traits of interest (because decrease of culling for udder, feet and legs, reproduction)
New traits under study: **lactation persistency**

EBVs on rams: criteria = coefficient of variation of test-day

Daily milk (ml)

Average lactation curve from divergent Lacaune rams
Pers -1 = persistency -
Pers 0 = persistency =
Pers 1 = persistency +

requires less concentrate in early lactation

optimize grazing in late lactation

2 genetic standard deviation
New traits under study: **fine milk composition**

- **Fine milk composition**
  - Fatty acid & protein
  - + mineral,
  - + metabolic disorders,
  - + body tissue mobilization,
  - + reproduction status

- Estimation equations
- Mid InfraRed spectrometry

- F%
- P%
New traits under study: resistance to parasites

In France: protocol of experimental infections applied to rams

- Important phenotypic variability between rams
- Moderate $h^2$ (0.20-0.40)

Increase resistance of rams to gastro-intestinal parasites:

- Decrease economic losses
- Increase animals’ health & welfare
- Mitigate use of chemical treatment
- Fight resistance to anthelmintic
- Improve quality of soil (increase coprophagous beetle)
Efficiency and resilience in the SMARTER project

**Improving efficiency and resilience**

- Focus on efficiency of feed resource used by animals
- Ability of an animal/system to either maintain or revert quickly to high production and health status when exposed to a diversity of challenges
- Feed efficiency, dynamics of body tissue mobilization, impact on the environment (GHG)
- Parasitism, footrot, mastitis, lamb survival, neonatal vigour, functional longevity
Benefit from international cooperation

Harmonization of phenotypes

Across-countries genetic and genomic evaluation

Towards across countries breeding organization
Conclusion

✓ Classical selection has worked in French dairy sheep ... but it has been a long and not-so-easy-to-reproduce process

✓ Genomic selection opens new opportunities to generate more (diversified) genetic gain (but not as much as in dairy cattle). International cooperation should be useful in the future

✓ To face new challenges (eg. global warming)
  o Either artificialize production system (eg. housing) 😞
  o Or adapt the animals 😊
    • Selection on-farm => progressive adaptation
    • Select for new specific traits such as resistance to diseases, efficiency and resilience

=> Balanced genetic goals for sustainability
New breeding goals and role of genomics on adaptation and resilience traits: the case study of French dairy sheep

Jean-Michel ASTRUC,
Diane BUISSON, Hélène LARROQUE, Gilles LAGRIFFOUL

EAAP Annual Meeting 2018 Dubrovnik (Croatia)
Session 65: Practices and prospects for adapting to a challenging Mediterranean environment
30 Aug. 2018