INTROGRESSION OF WOOL-SHEDDING GENES INTO THE ROMANE BREED SHEEP

D. Allain\textsuperscript{1}, B. Pena\textsuperscript{1}, D Foulquié\textsuperscript{2}, Y. Bourdillon\textsuperscript{3} and D. François\textsuperscript{1}.

\textsuperscript{1} INRA UMR GenPhySE, Auzeville. CS52627. 31326 Castanet Tolosan. France
\textsuperscript{2} INRA UE La Fage, 12250 Roquefort sur Soulzon, France
\textsuperscript{3} INRA UE Bourges, La Sapinière, 18390 Osmoy, France

EAAP 2014 – session 36: Fur, Fibre and skin animal products
Context

sheep industry to day

• European countries
  – wool : generally not profitable
    • often undesirable compared to meat or milk
    • income from wool < shearing and wool associated costs
  – New interest for breeds with no wool or shedding wool
    • Hair sheep : Wiltshire, Barbados Blackbelly, Dorper, ….
    • Crossbreds with hair sheep

Back to a wool shedding sheep from a modern meat sheep ?
Back to a wool shedding sheep?

From the Romane breed: a composite line
- « Berrichon du cher » X « Romanov »
  - 4 intercrossing generations
- a modern sheep selected for meat production and adaptive traits: prolificacy and maternal abilities
  - Large variability fleece type: long wool $\rightarrow$ kempy fleece

1. Genetic variability of wool shedding
- In the Romane breed

2. Introgression of wool-shedding genes
- into the Romane breed sheep
- from the Martinik Black Belly breed:
  - a hair sheep from French West Indies (Caribbeans)
Wool sheeding measurements

Wool shedding measurement

- Once a year (summer onset)
  - before annual shearing time
  - ~ end of spring shedding period
  - use of standard sheep profile

  » Drawn body surface with wool
  » Each animal

- Image analysis software
  ✓ Extent of wool shedding
  \[
  \text{Extent of wool shedding} = \frac{\text{body surface without wool}}{\text{total body surface}}
  \]

2 pure Romane flocks

- 300 adult ewes
  ✓ from 1. to 5 years age
  ✓ from 2002 to 2013

- Lambs and young ewes
  ✓ at 7mo, and 19 mo of age
  ✓ for 3 years (2009 – 2011)

1 Introgressed flock

- lambs at 4 - 7 mo age
- ewes 1 & 2 y. age
- from 2011 to 2013
Introgression of wool shedding genes from Martinik Black Belly into Romane breed
4 successive backcrossing generations

Step 1 up to BC1

4 Martinik BB rams

Romane ewes

Romane ewes

4 F1 sires

No wool shedding measurements

Backcross1

33 Backcross1 males

wool shedding measurements at 7 and 19 mo.

6 BC1 sires selected for total shedding → Step 2
Introgression of wool shedding genes

<table>
<thead>
<tr>
<th>Introgression 2\textsuperscript{nd} step up to BC3</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
</tr>
<tr>
<td>6 BC1 sires</td>
</tr>
<tr>
<td>120 Romane ewes 10 mo</td>
</tr>
<tr>
<td>10 BC2 sires</td>
</tr>
<tr>
<td>180 Romane ewes 10 mo</td>
</tr>
<tr>
<td>BC3: shedding Romane</td>
</tr>
</tbody>
</table>

Lamb selection for shedding extent at 4 and/or 7 mo

- rams
- ewes

Young ewes shedding extent at 19mo

Part shedding at 9mo.

Selection on wool shedding

- 2009
- 2010
- 2011
- 2012
- 2013

Introgression

D. Allain et al / Introgression of wool-shedding genes into the Romane breed sheep

EAAP 2014, Copenhagen, Denmark
Data analysis

• Traits
  – Ability to shed: binary trait
  – Wool shedding extent: categorical trait (8 classes)

• 3 datasets
  – Lambs and young ewes Romane breed at 9 and 21 mo
    • 1503 animal records at 9 and 21 mo, 3385 animals in pedigree
  – Adult Romane ewes: 1259 animals with performances
    • 2984 records, 2485 animals in pedigree
  – Introgressed Romane population:
    • 416 animals with performances: lambs at 4-7 mo. and ewes at 1-2 y

• Methods
  – Threshold model using TM software (Bayesian inference)
  – Fixed effects: age of ewe, year, age of dam, born and suckling lambs
    • Birth and rearing type on 2nd dataset (lambs at 9 mo)
  – Random effects: genetic additive, permanent environment and residual
1- Genetic variability of wool shedding *lambs* and young *Romane* ewes

- **Genetic parameters as separate traits**
  - **7 mo lambs**
    - Wool-sheeding extent classes:
      - Green: 7mo
      - Blue: 19mo
    - 23% 7 mo lambs shed partly
    - 53% 19 mo ewes shed partly
    - 1.2%
  - High positive genetic correlation
  - Selection at lamb age

- **19 mo ewes**
  - Wool-sheeding extent classes:
    - Green: 7mo
    - Blue: 19mo
  - 0.73 ± 0.11
  - 0.42 ± 0.05
  - 0.86 ± 0.19

**Table:**

<table>
<thead>
<tr>
<th></th>
<th>Lamb 7 mo age</th>
<th>Young ewe 19 mo age</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 mo lambs</td>
<td>0.73 ± 0.11</td>
<td>0.86 ± 0.19</td>
</tr>
<tr>
<td>19 mo ewes</td>
<td>0.42 ± 0.05</td>
<td></td>
</tr>
</tbody>
</table>
1- Genetic variability of wool shedding adult Romane ewe

Variation factors

- Age of ewe
  - 1 year old shed less than others
  - No variation thererafter

- Reproduction activity
  - Ewe producing and suckling lambs shed more than others

\[ h^2 = 0.69 \pm 0.05 \]

But long selection process!
Introgressed Romane population (I.R.) wool shedding in lambs & young ewes

Lambs (7mo) and Young ewes (19mo)

- Pure Romane*
- 1st I.R. G2011
- 2nd I.R. G2012
- 3rd I.R. G2013

Large increase of wool shedding in I.R. animals

* Control pure Romane animals measured at same age and same time

$h^2 = 0.50 \pm 0.09$

1 $\sigma_g$ genetic gain from 1$^{st}$ to 3$^{rd}$ I.R. generation
Conclusions

Variability of wool shedding in the pure Romane breed

- High genetic correlation (0.86) lamb → young ewe traits
  - Selection at lamb stage
- High heritability (0.69) estimate in adult ewes
- But as only a few animals (1-2%) shed total fleece annually

Introgression of wool shedding genes from Martinik Black Belly

Through 4 successive backcrossing generations with selection on wool shedding on lambs along introgression process

- Large increase of wool shedding
  - at the end of backcrossing process
  - thereafter by selection (2 generations)
    - In both lambs and adult ewes

Long selection process up to a shedding sheep

Efficient P-MAS* strategy up to a shedding sheep

* phenotype-marker assisted selection
Acknowledgements

- INRA UMR GenPhySE
  - B. Pena-Arnaud
- INRA Domaine de La Fage
  - D. Foulquié
- INRA Domaine de Bourges
  - Y. Bourdillon

Thank you for your attention
Introgressed shedding Romane animals

7 mo ♀ lambs

2.5 y adult ewes

7 mo ♂ lambs

4 mo ♀ lamb

source: D. Allain
Martinik BB, Romane & crossesbreds

Romane rams

source: OS Romane

Martinik ewe

source: D. Allain

F1

source: D. François

all F1 animals shed

Romane Martinik BC1

source: D. Allain

some BC1 animals shed
The Romane sheep breed

A composite line of 2 breeds intercrossed during 4 generations

Berrichon du Cher: meat breed having a white fleece with merino infusion

Romanov: prolific breed having a black coarse fleece

Selection goals: prolificacy, milking ability, adaptive traits

Large variability in fleece type: long wool → kempy fleece
The Martinik Black Belly Breed

A hair sheep from French West Indies
related to the other hair sheep populations present in the Caribbean Islands and Central America (Barbados Blackbelly, Pelibuey, West African)

Selection goals: prolificacy, milking ability, adaptive traits (nematode resistance)
Martinik – Romane crossbreds

F1 animals
all F1 animals shed

Backcross 1
Romane Martinik
some BC1 animals shed

source: D. François

source: D. Allain
General pattern of wool shedding extent

1- No shedding

Antero-posterior and ventro-dorsal gradient

6- Total wool shedding
Fleece evolution from ancestral sheep towards modern woolled sheep for textile use

Wild hair sheep
- Guard hair (kemp)
- Fine woolly undercoat
- Seasonal growth and shedding

Medium wool sheep
- Coarse long wool with kemp for spinning
- Permanent fibre growth requiring shearing

Merino sheep
- Fine wool only
- For fine yarn
Fleece evolution from ancestral sheep towards modern woolshedded sheep for textile use

Wild hair sheep
- Guard hair (kemp)
- Fine woolly undercoat
- Seasonal growth and shedding

Medium wool sheep
- Coarse long wool with kemp for spinning
- Permanent fibre growth requiring shearing

Merino sheep
- Fine wool only
- For fine yarn

Back to a wool shedding sheep?