CLUSTERING AND GENETIC ANALYSIS OF BODY RESERVES CHANGES THROUGHOUT PRODUCTIVE CYCLES IN MEAT SHEEP

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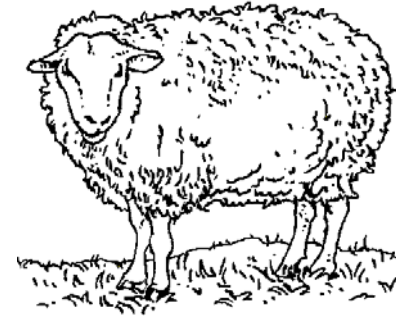
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Plan

➢ Context - Robustness

➢ Cluster analysis
  ➢ Materials and methods
  ➢ Results

➢ Genetic analysis
  ➢ Materials and methods
  ➢ Results

➢ Discussion – Conclusion

➢ Perspectives

Context - Robustness

➢ Robust animals to assure the farm sustainability in harsh conditions or in more controlled conditions (sheepfold)

➢ One component of robustness: mobilization/accretion of body reserves (BR) through lipids metabolism

Russel *et al.,* 1971
Blanc *et al.,* 2006

Context - Robustness

➢ Robust animals to assure the farm sustainability in harsh conditions or in more controlled conditions (sheepfold)

➢ One component of robustness: mobilization/accretion of body reserves (BR) through lipids metabolism

Productivity

Survival

Ability to mobilize or restore body reserves

Health

Reproduction
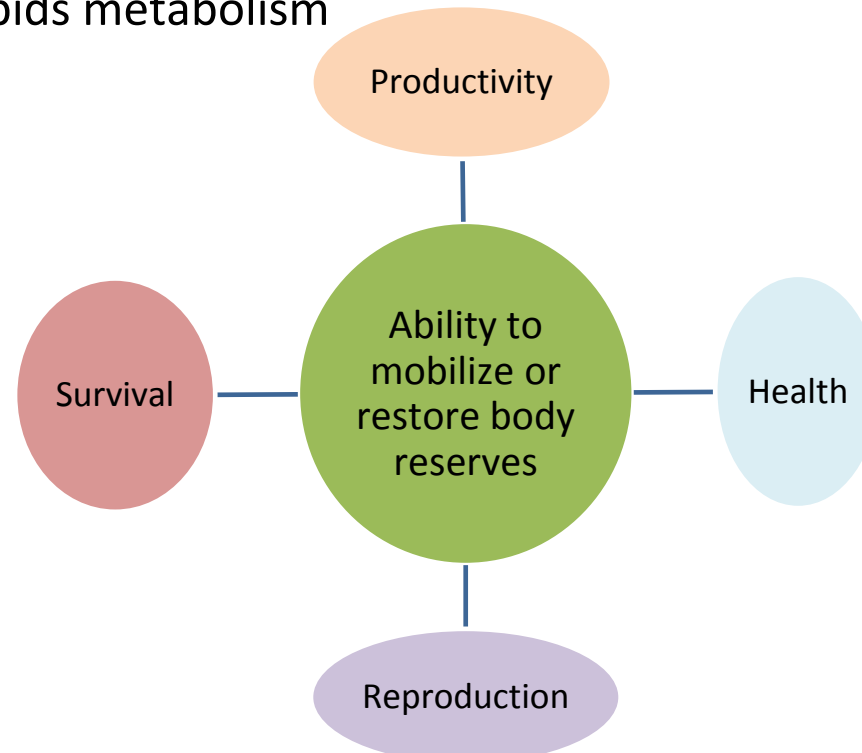
Russel *et al.,* 1971
Blanc *et al.,* 2006

Context - Robustness

➢ Body Condition Score use to characterize robustness
  o Score from 1 to 5: lean to fat
  o Optimum between 2.5 and 3.5

➢ Heritability of BCS when considered as a punctual measurement
  o From 0.10 to 0.45 for ruminants

➢ No study in ruminants on genetic for BCS when considering variations along productive cycle (successive measurements)

Russel *et al.,* 1971
Borg *et al.,* 2005
Loker *et al.,* 2011
Shackell *et al.,* 2011

Context - Robustness

➢ Objectives

    o To investigate temporal changes and profiles of BR dynamics throughout productive cycles

    o To analyze the genetic variability of BR dynamics in meat sheep
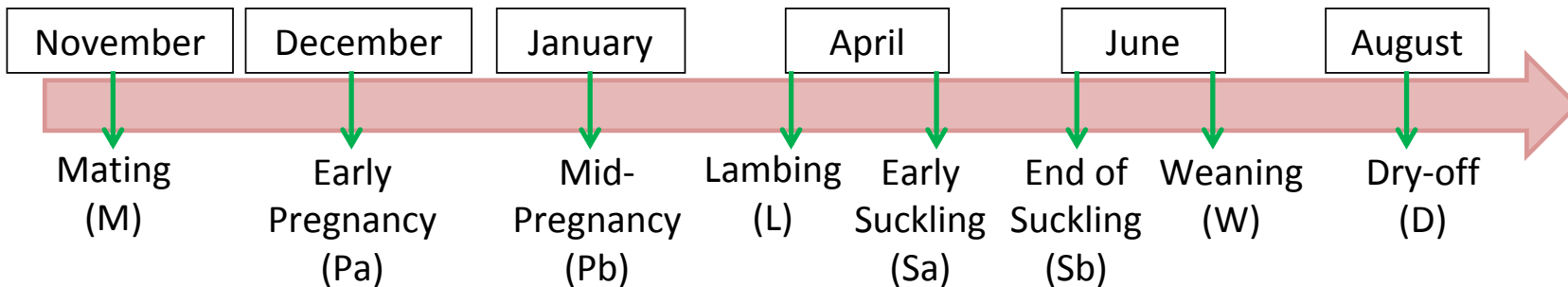
Materials and Methods

➢ Romane flock (n=250 ewes) reared exclusively outdoors in harsh conditions on a plateau (near Roquefort, La Fage)

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➢ BCS measured on 1146 ewes from 78 sires (2002-2015)
- Cycle 1: 1146
- Cycle 2: 1068
- Cycle 3: 414

➢ 8 BCS measurements per productive cycle

November	December	January	April	June	August

Mating (M) — Early Pregnancy (Pa) — Mid-Pregnancy (Pb) — Lambing (L) — Early Suckling (Sa) — End of Suckling (Sb) — Weaning (W) — Dry-off (D)

Materials and Methods – Cluster analysis

> Clustering

- To investigate variability in individual BCS profiles

- Smoothing (51 nodes)

- Functional Principal Component Analysis (FPCA)

- Clusters construction
  - Three first components of FPCA
  - Expectation-Maximization Algorithm
  - Repeatability and stability of clusters (n=2 to 7 clusters)

Clusters

Composant 2
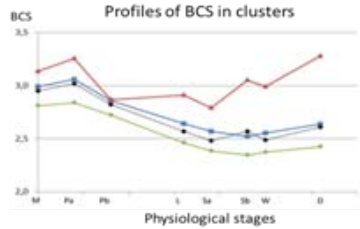
Composant 1
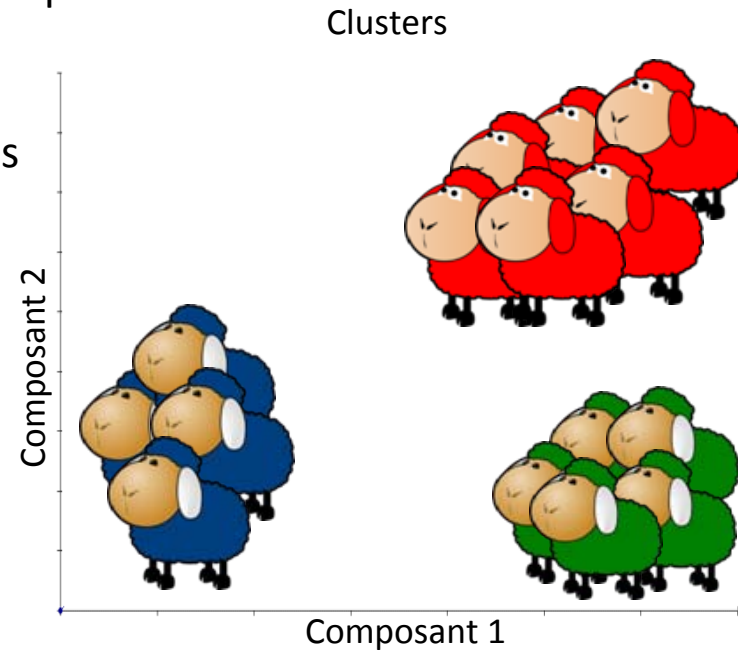
Results - Clusters analysis
Cycle 1

Clusters

Profiles of BCS in clusters
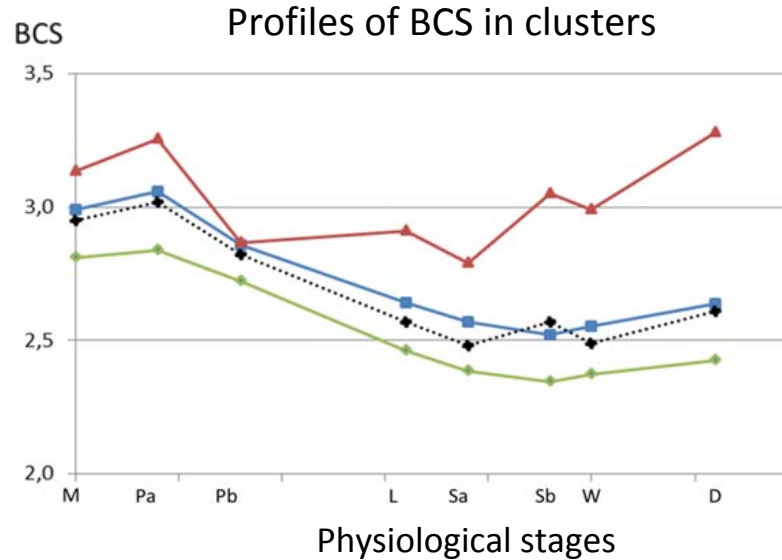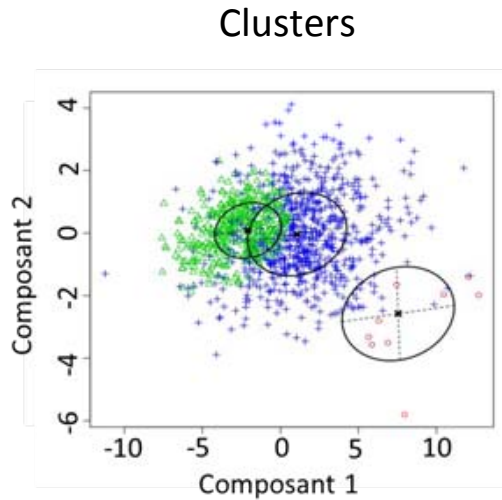
Clusters	% of ewes
B1 (blue)	63
B2 (green)	36
B3 (red)	1
Mean (black dots)	

➢ Three clusters identified at cycle 1

➢ Two main clusters with similar profiles but differing in level of BCS
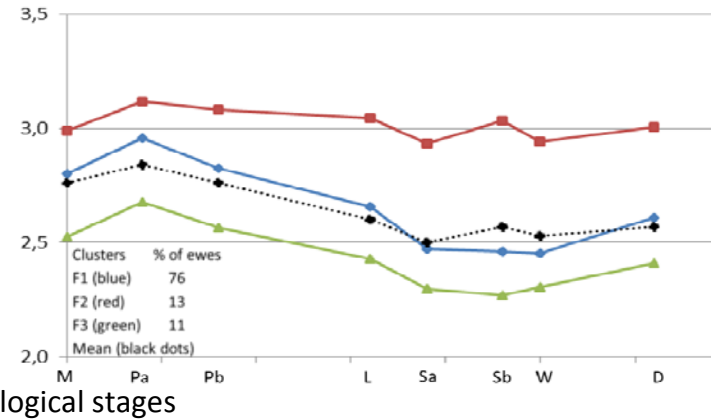
Results - Cluster analysis

Profiles of BCS in clusters

Profiles of BCS in cluster at cycle 2

Profiles of BCS in cluster at cycle 3

Clusters | % of ewes
D1 (blue) | 55
D2 (green) | 30
D3 (red) | 15
Mean (black dots)

Clusters | % of ewes
F1 (blue) | 76
F2 (red) | 13
F3 (green) | 11
Mean (black dots)

Physiological stages
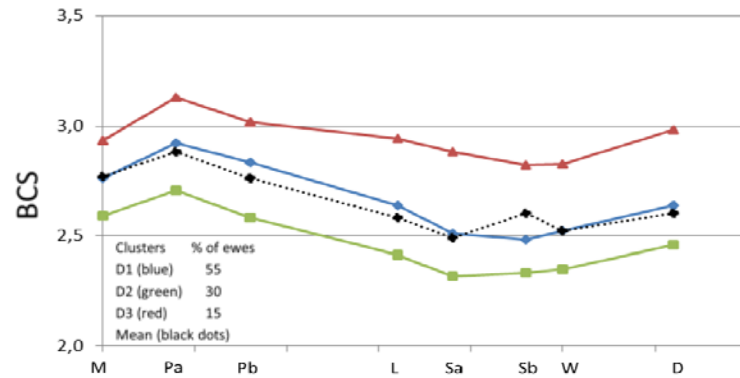
- ✓ 56 % of D1 came from B1
- ✓ 53 % of D2 came from B2
- ✓ 64 % of D3 came from B1

- ✓ 56 % of F1 came from D1
- ✓ 47 % of F2 came from D1
- ✓ 74 % of F3 came from D2

➢ Three clusters identified at cycles 2 and 3

➢ Majority of clusters showed similar profiles along cycle but differed in BCS levels

➢ Biological effects

Materials and Methods – Genetic Analysis

➢ Trait = Difference in BCS between two physiological stages

➢ Example of four traits

Traits for BCS
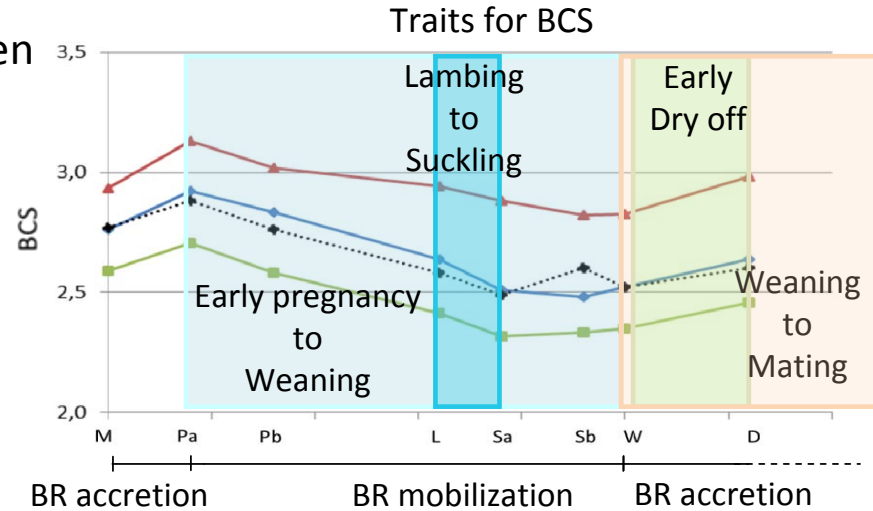
➢ Univariate and multivariate analysis: Heritabilities and correlations estimation with animal model (ASReml, all cycles considered)

Y = mu + animal + perm + age + parity + litter + year + e
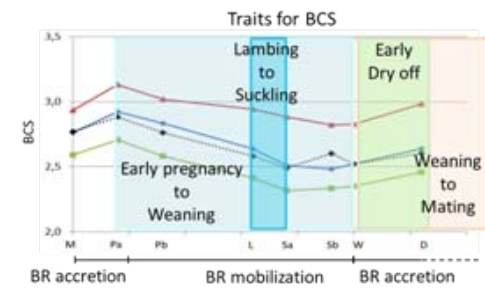
Y: trait

mu: mean of the trait

animal: additive genetic effect of the ewe

perm: environmental permanent effect of the ewe

age of the ewe, parity, litter, year of measurements as fixed effects

e: residual

Results - Genetic Analysis

Traits for BCS

Variables BCS	Early pregnancy to Weaning	Lambing to Suckling	Early dry-off	Weaning to Mating
Early pregnancy to Weaning	**0.14** (0.02)			
Lambing to Suckling		**0.07** (0.02)		
Early dry-off			**0.15** (0.02)	
Weaning to Mating				**0.11** (0.04)

➤ Low to medium heritabilities (0.07 ± 0.02 to 0.15 ± 0.02)

Results - Genetic Analysis

Variables BCS	Early pregnancy to Weaning	Lambing to Suckling	Early dry-off	Weaning to Mating
Early pregnancy to Weaning	**0.14** (0.02)	0.49 (0.12)		
Lambing to Suckling		**0.07** (0.02)		
Early dry-off			**0.15** (0.02)	
Weaning to Mating				**0.11** (0.04)

➢ Positive correlation between periods characterizing BR mobilization

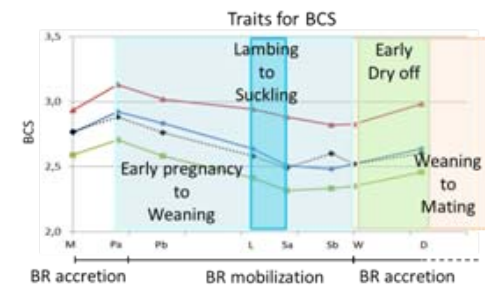# Results - Genetic Analysis

Variables BCS	Early pregnancy to Weaning	Lambing to Suckling	Early dry-off	Weaning to Mating
Early pregnancy to Weaning	**0.14** (0.02)	0.49 (0.12)		
Lambing to Suckling		**0.07** (0.02)		
Early dry-off			**0.15** (0.02)	0.75 (0.10)
Weaning to Mating				**0.11** (0.04)

➤ Positive correlation between periods characterizing BR accretion

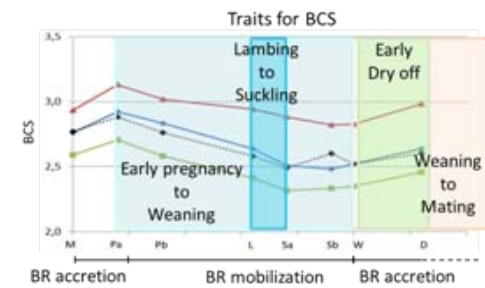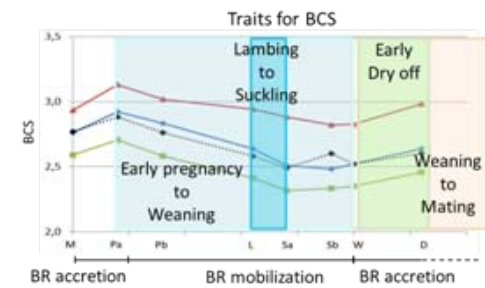# Results - Genetic Analysis

Variables BCS	Early pregnancy to Weaning	Lambing to Suckling	Early dry-off	Weaning to Mating
Early pregnancy to Weaning	**0.14** (0.02)	0.49 (0.12)	-0.71 (0.08)	-0.73 (0.14)
Lambing to Suckling		**0.07** (0.02)	-0.46 (0.12)	-0.52 (0.18)
Early dry-off			**0.15** (0.02)	0.75 (0.10)
Weaning to Mating				**0.11** (0.04)

➢ Negative correlations between periods characterizing BR accretion and mobilization

Discussion - Conclusion

➢ Variability in BR dynamics

      o Three clusters at each cycle

      o Most of profiles with similar dynamic but differing in BR levels

      o Variation due to biological factors (litter size) AND individual differences

➢ BCS variations heritable: possibility of using it for selection

➢ Accretion and mobilization processes of BR linked at the genetic level

      o Common genes?

Discussion - Conclusion

➢ Perspectives

o Link with zootechnical performances (lamb growth, ewe reproduction…)

o Longitudinal genetic modeling (Random Regression) of the BCS variations profiles

o Joint analysis with climatic data (reaction norm model)

o Further phenotyping for BR variations (key metabolites /hormones /ultra sound measurements…)

Take home message

➢ Variability in BR dynamics

➢ BCS variations heritable: possibility of selection

➢ Accretion and mobilization of BR linked at the genetic level

Results – Genetic Analysis

Estimates (± standard errors) of variance components for BCS.

Variables	h^2	c^2	e^2	r	σ^2_p
BCS-M	0.35 (0.04)	0.03 (0.03)	0.62 (0.02)	0.38 (0.02)	0.04 (0.00)
BCS-Pa	0.37 (0.04)	0.04 (0.03)	0.60 (0.02)	0.40 (0.02)	0.05 (0.00)
BCS-Pb	0.32 (0.03)	0.04 (0.03)	0.64 (0.02)	0.36 (0.02)	0.05 (0.00)
BCS-L	0.26 (0.04)	0.10 (0.03)	0.64 (0.02)	0.36 0.02)	0.04 (0.00)
BCS-Sa	0.27 (0.03)	0.04 (0.03)	0.69 (0.02)	0.31 (0.02)	0.04 (0.00)
BCS-Sb	0.26 (0.05)	0.05 (0.05)	0.69 (0.04)	0.31 (0.04)	0.05 (0.00)
BCS-W	0.33 (0.04)	0.05 (0.03)	0.61 (0.02)	0.39 (0.02)	0.05 (0.00)
BCS-D	0.33 (0.04)	0.06 (0.03)	0.61 (0.02)	0.39 (0.02)	0.04 (0.00)

h^2: heritability; c^2: proportion of total phenotypic variance due to ewe permanent environmental effect; e^2: proportion of total phenotypic variance due to temporary environmental effects; r: repeatability; σ^2_p: total phenotypic variance.

Results – Genetic Analysis

Estimates (± standard errors) of variance components for BCS variations.

Variables	h^2	C^2	e^2	r	σ^2_p
BCS-M:Pa	0.07 (0.02)	0.00 (0.02)	0.92 (0.02)	0.08 (0.02)	0.041 (0.001)
BCS-Pa:W	0.16 (0.03)	0.02 (0.03)	0.83 (0.02)	0.17 (0.02)	0.056 (0.002)
BCS-Pa:L	0.10 (0.02)	0.02 (0.02)	0.88 (0.02)	0.12 (0.02)	0.055 (0.001)
BCS-L:Sa	0.04 (0.02)	0.04 (0.02)	0.92 (0.02)	0.08 (0.02)	0.030 (0.001)
BCS-W:D	0.10 (0.03)	0.01 (0.03)	0.89 (0.03)	0.11 (0.03)	0.032 (0.001)
BCS-W:M	0.10 (0.04)	0.01 (0.05)	0.89 (0.05)	0.11 (0.05)	0.039 (0.002)

h^2: heritability; c^2: proportion of total phenotypic variance due to ewe permanent environmental effect; e^2: proportion of total phenotypic variance due to temporary environmental effects; r: repeatability; σ^2_p: total phenotypic variance.

Results – Genetic Analysis

CV
BCS-Pa:W 22%
BCS-L:Sa 32%
BCS-W:D 52%
BCS-W:M 25%