iSAGE Training Course and Workshop

INNOVATIONS TO IMPROVE SUSTAINABILITY IN THE SHEEP AND GOAT SECTOR
(Zaragoza, Spain, from 10 to 13 December 2019)

Genetic approaches to improve sustainability and adapting to climate change (WP5)

→ novel phenotypes for improving animal resilience/adaptability :

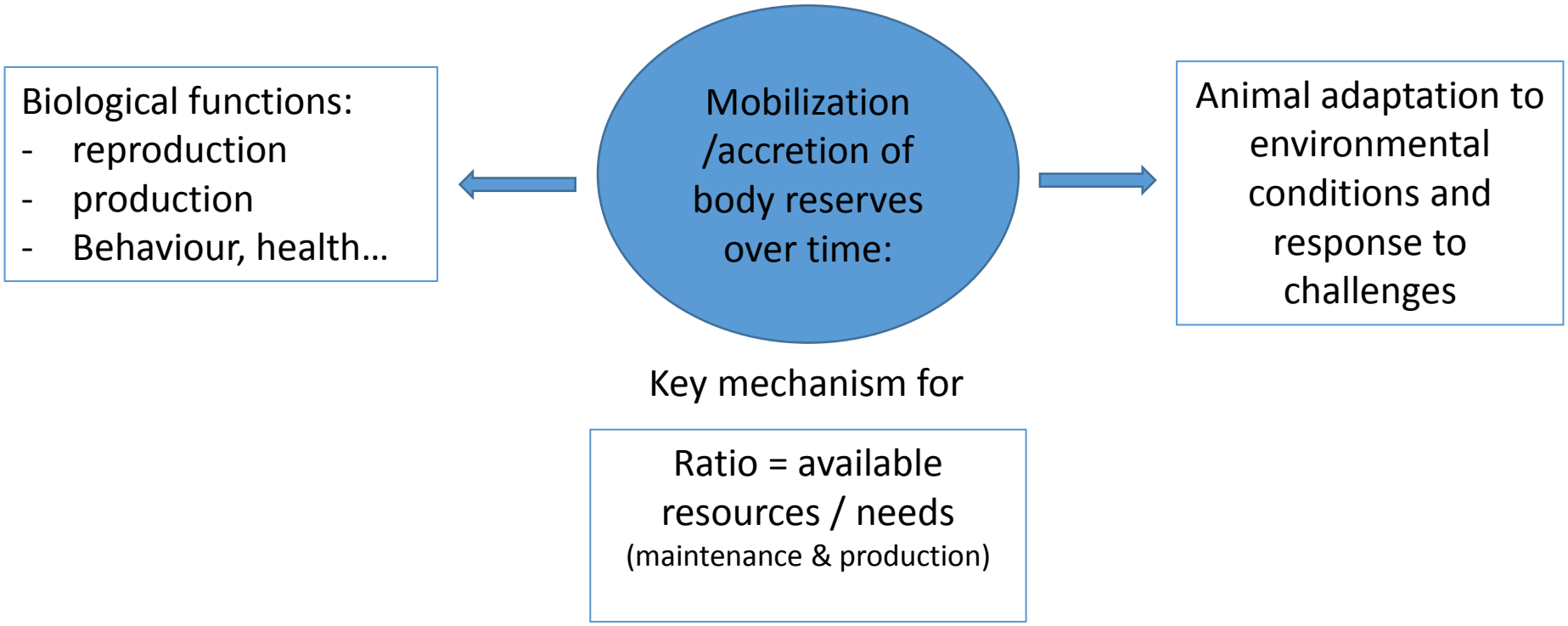
The body reserves mobilization-accretion process

Dominique Hazard et al. (dominique.hazard@inra.fr)

Innovation for Sustainable Sheep and Goat Production in Europe

iSAGE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 679302.

Body reserves dynamics – Why ?



Hypothesis = Animals better adapted or more resilient may show a better management of body reserves

Objective in farms : ↑ **Contribution of animals to managing the ratio** ↓ **Contribution of farmers to managing the ratio**

Experimental facilities:

INRA experimental farm La Sapinière
(Bourges, centre of France)

INRA experimental farm La Fage
(Roquefort sur Soulzon, south of France)

Meat sheep : Romane

intensives conditions

- Exclusively indoor
- high inputs system
- 1rst and 2nd mating = 10 and 18 month of age, respectively

Meat sheep : Romane

extensive conditions

- Exclusively outdoor
- One lambing /year (in April)
- Harsh environment: high seasonal variations (feed quality and quantity)
- Low inputs system (1 ewe/ha)

Dairy sheep : Lacaune

Semi-intensive conditions

- Indoor and outdoor
- One lambing /year (in December or January)
- Grazing (6 months : April to October)

Phenotypes:

Meat sheep : Romane

intensives conditions

N=65 primiparous ewes
N=63 multiparous ewes

Meat sheep : Romane

extensives conditions

N=180 primiparous
N=220 multiparous

Dairy sheep : Lacaune

Semi-intensive conditions

N=220 primiparous ewes
N=250 multiparous ewes

Phenotypes :

- Body reserves (BR): Body Condition Score, Body weight, key metabolites and hormones associated with lipids metabolism
- Longitudinal phenotyping (3 to 6 points / 1 to 2 productive cycles): mating, early pregnancy (2months), late pregnancy (2weeks before lambing), suckling (3 weeks after lambing), weaning

Genotypes :

15K and 50K SNP beadchip

Objective: characterize novel phenotypes for BR and investigate genetic determinism

Phenotypes:

❖ **Body Condition Score:**

→ from the original grid described by Russel et al. (1969)

→ A scale from 1 to 5 (0.25 or 0.1 increments)

❖ **Key metabolites and hormones** associated with lipids metabolism :

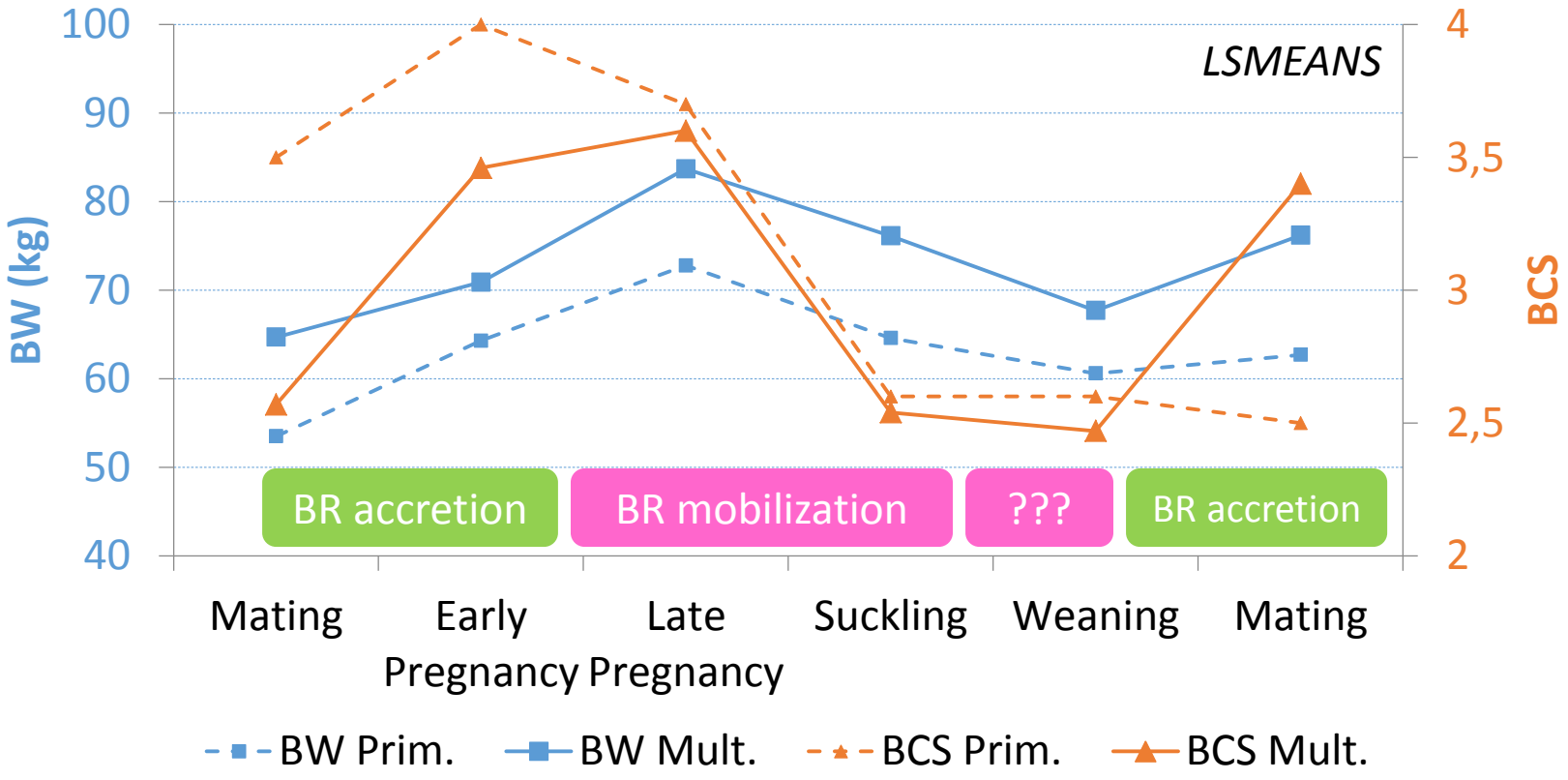
→ Blood sampling (plasma)

- Non Esterified Fatty Acids (NEFA) : produced by adipose tissue during BR mobilization
- Beta-hydroxybutyrate (BOHB) : produced by liver tissue during use of fatty acids to produce energy
- Triiodothyronine (T3) : thyroid hormone produced to activate lipolysis

Body reserves at physiological stages

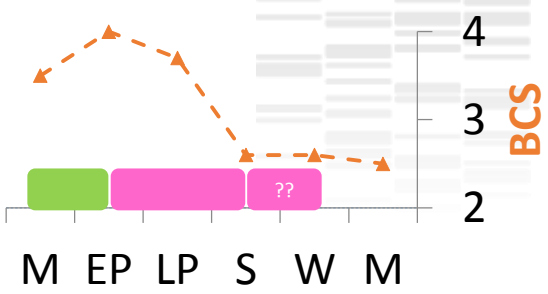
in Romane

intensives conditions



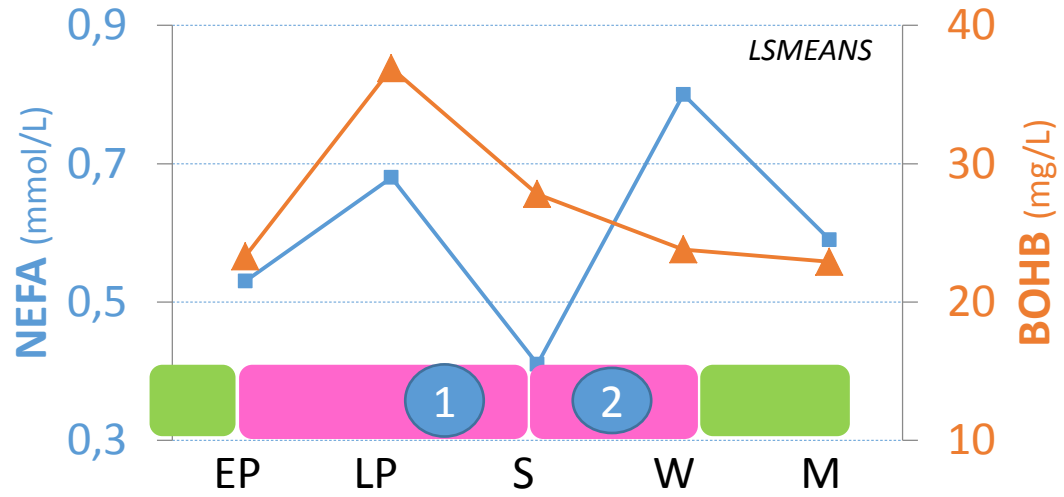
➔ Alternation of BR accretion and mobilization throughout a productive cycle

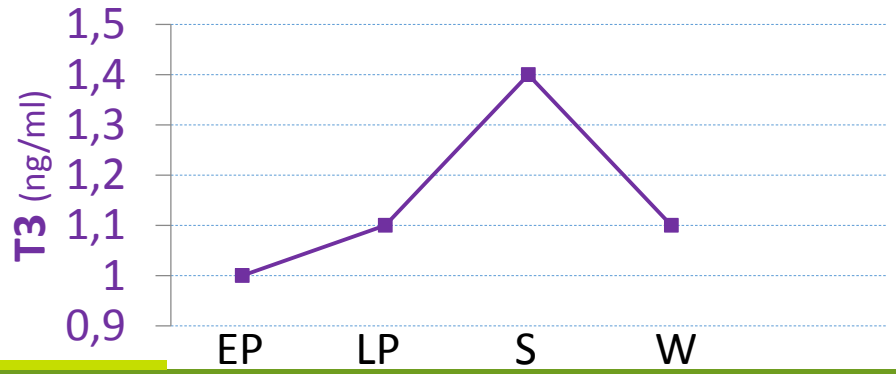
Biomarkers of Body Reserves



in Romane
Primiparous ewes

intensives conditions





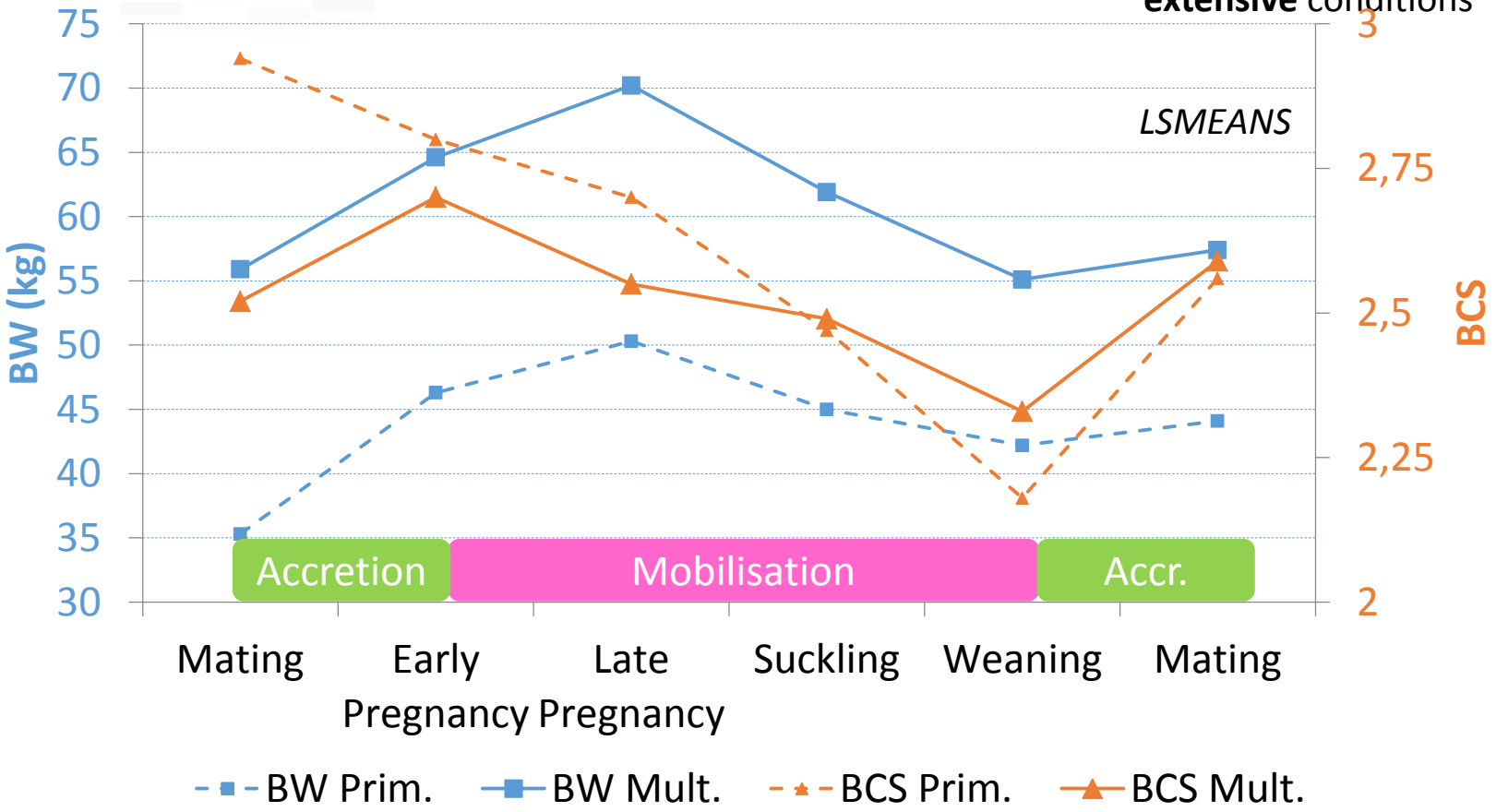
1 Braken of lipolysis

2 Activation of lipolysis

Body reserves at physiological stages

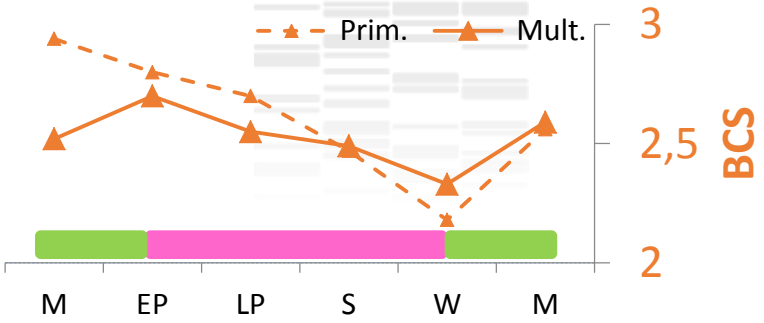
extensive conditions

in Romane



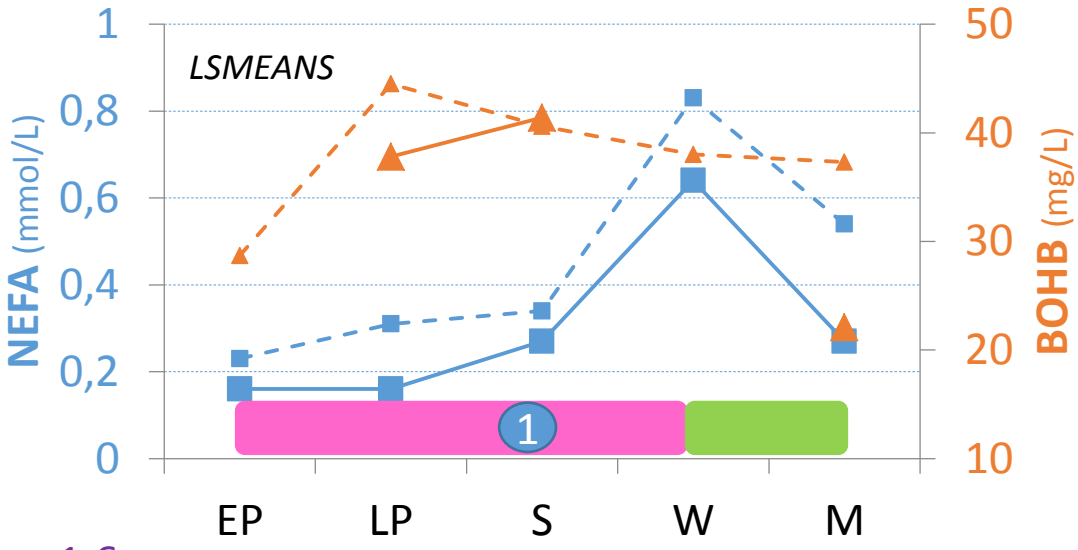
➔ Alternation of BR accretion and mobilization throughout a productive cycle

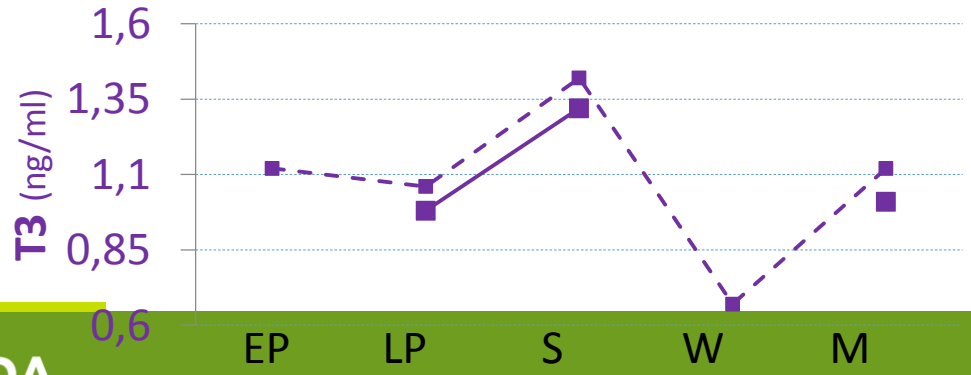
Biomarkers of Body Reserves



in Romane

extensive conditions



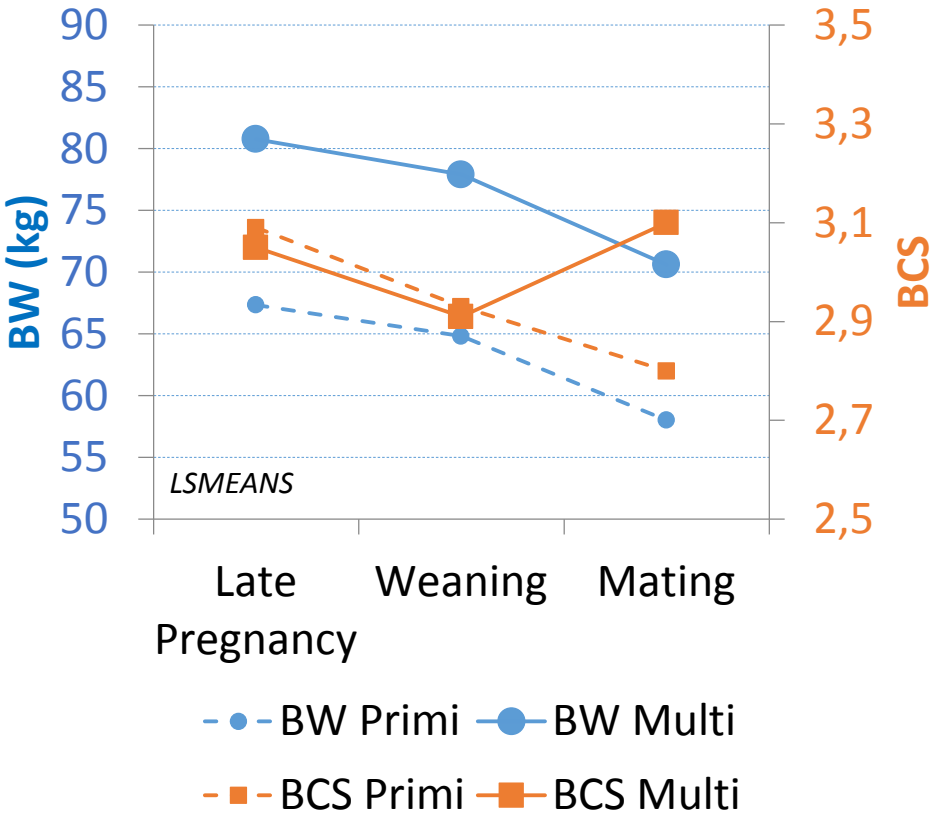


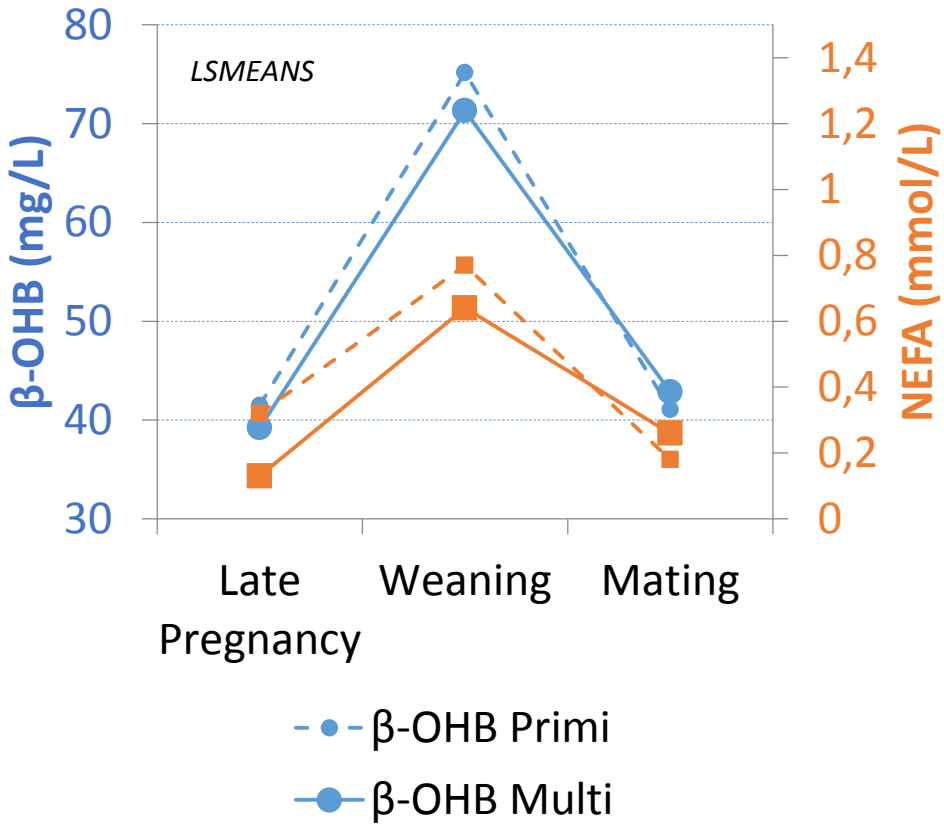
1 Increase of lipolysis

Body reserves at physiological stages

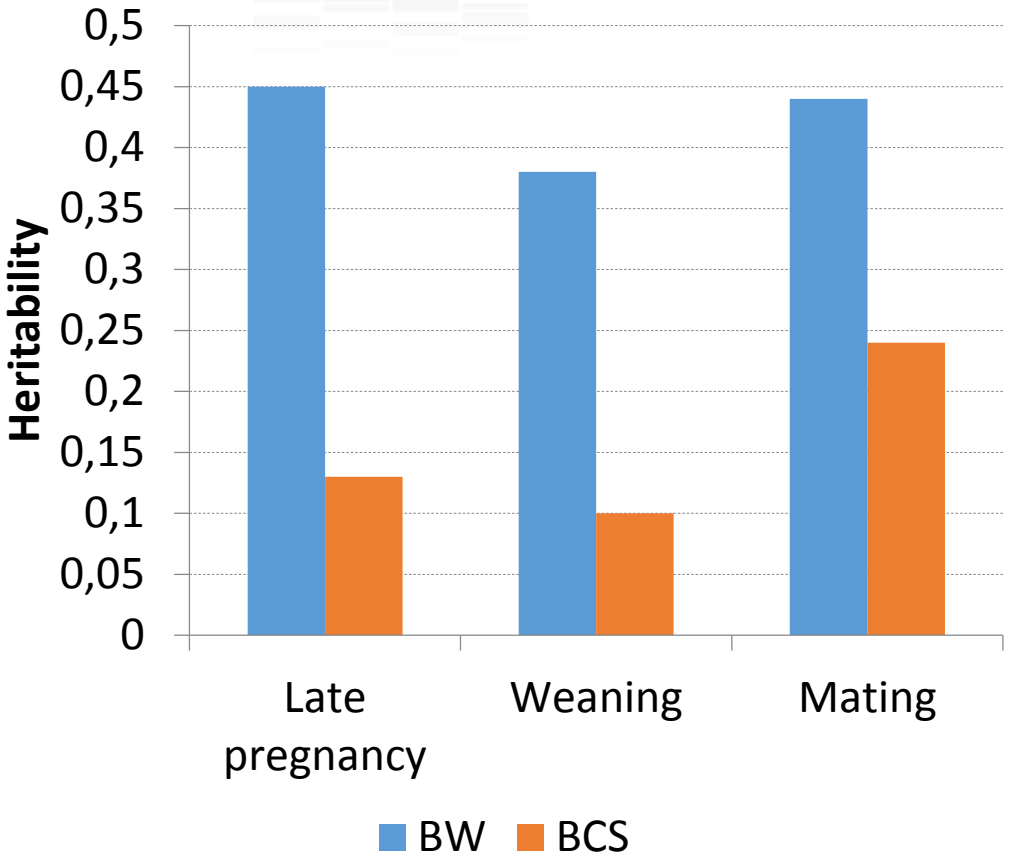
in Lacaune

Semi-intensive conditions





Body reserves levels: heritability in Lacaune



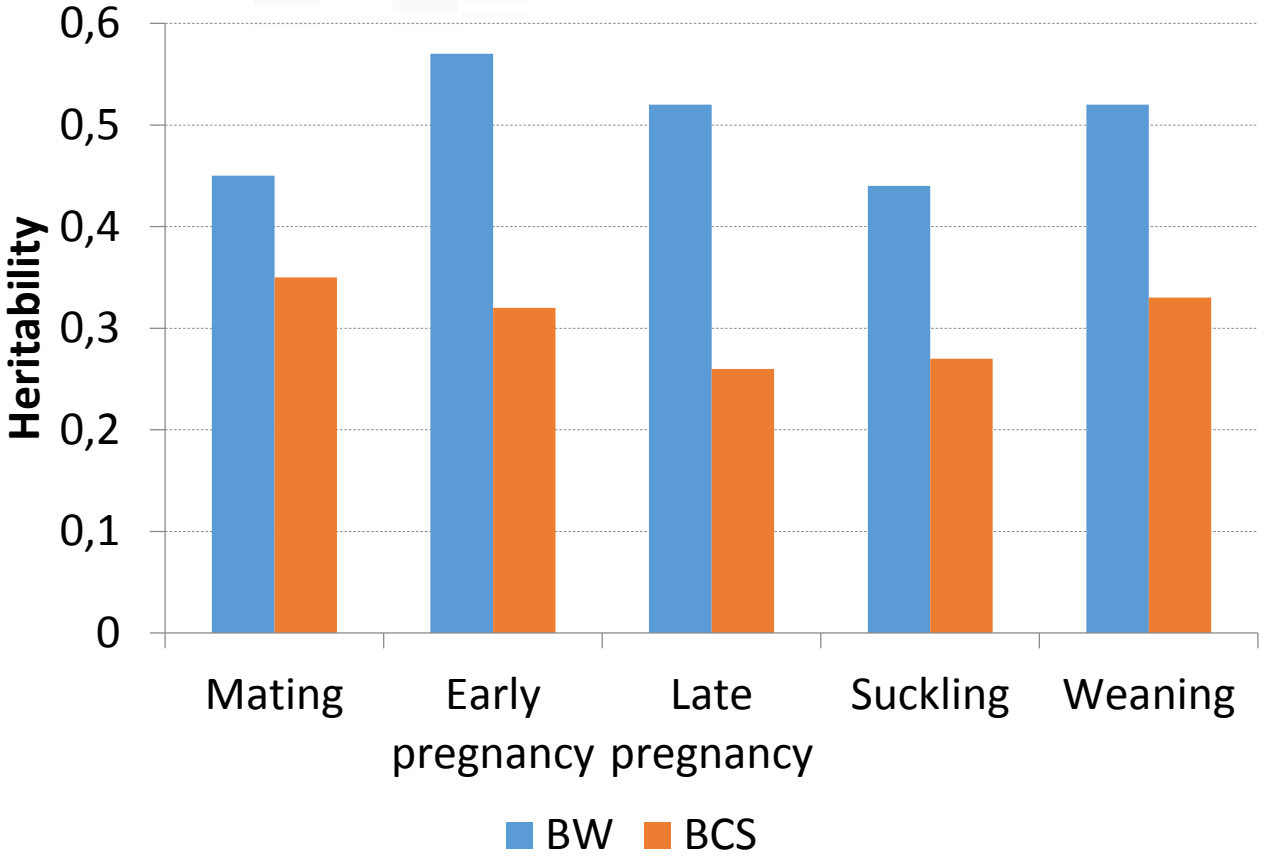
Genetic correlations:

	BW
BCS	**0 to 0.23** (±0.13)

➔ BCS are not related to BW

➔ BR levels are heritable traits.

Body reserves levels: heritability in Romane



Genetic correlations:

	BW
BCS	**NS to 0.32** (±0.13)

	BW at Weaning
BCS at Suckling	**0.50** (±0.10)

➔ BCS are somewhat related to BW

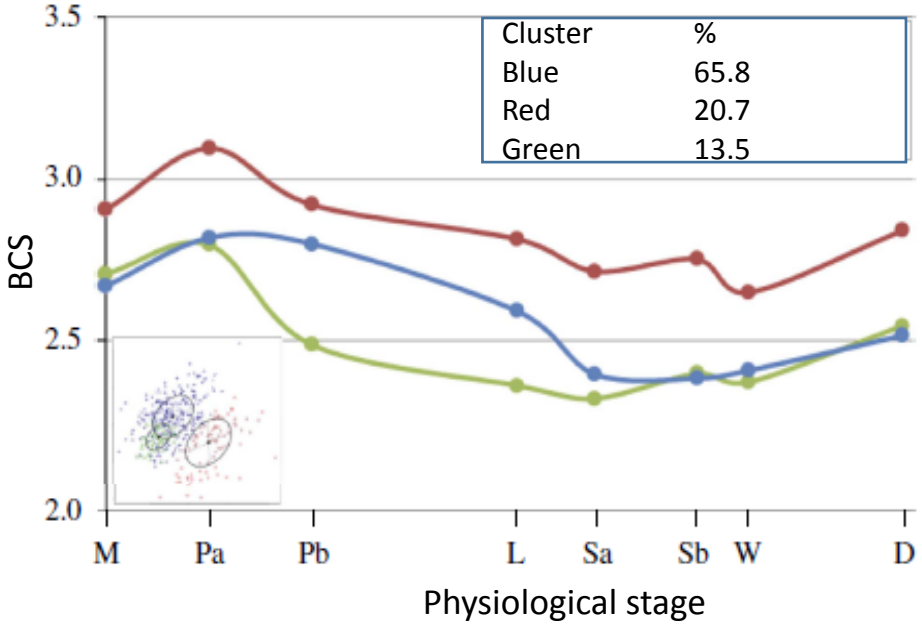
➔ BR levels are heritable traits.

Body reserves trajectories

in Romane

- Multiparous ewes (n~500, *background data*)
  - 2nd lambing
  - age = 2-3 years (2.5 in avg. in each cluster)
  - Litter size = 2 lambs (pregnancy and suckling)

extensive conditions



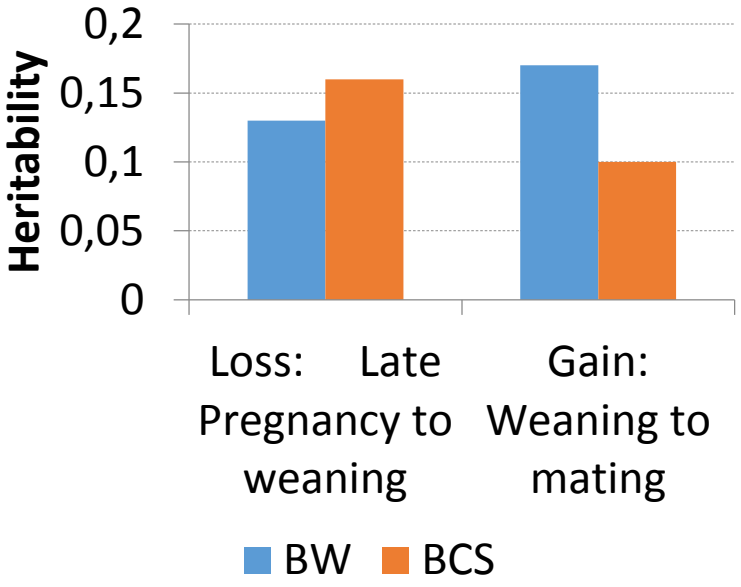
→ Three main groups of ewes differing by their BR trajectories.

Macé et al, Animal, 2018

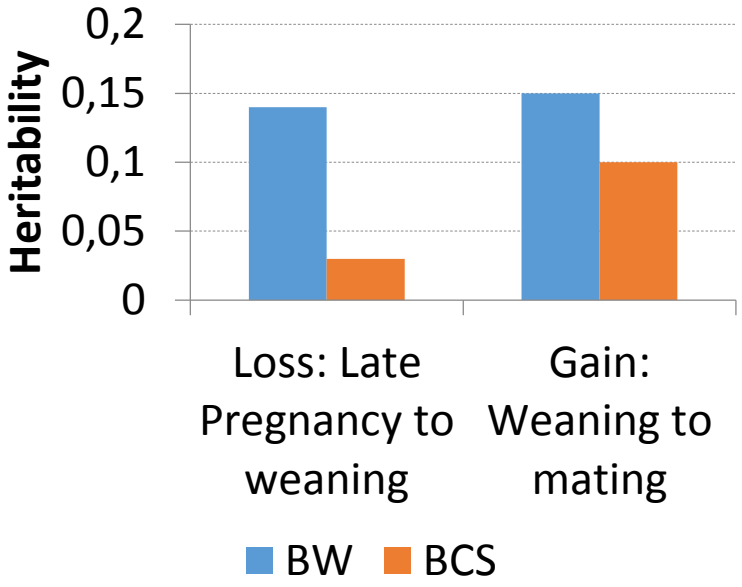
➔ Inter-individual variability in the level and the form of BR trajectories.

Body reserves changes over time: genetic parameters

in Romane



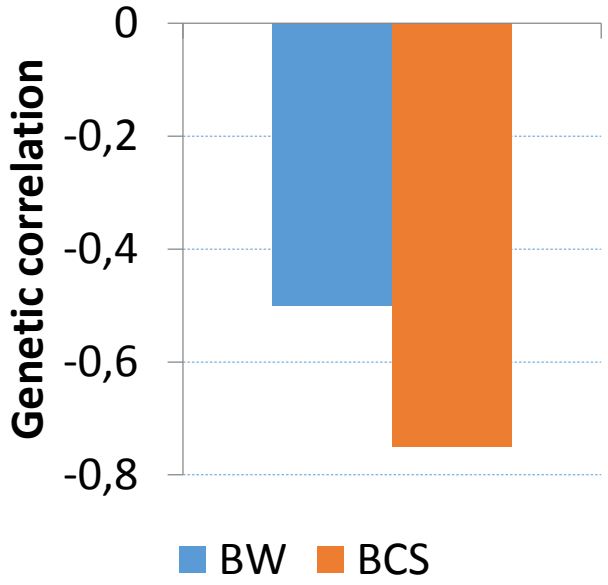
in Lacaune



➔ BR mobilization and accretion processes are heritable traits.

Body reserves changes over time:
genetic correlation between loss and gain

in Romane



in Lacaune

➔ No significant correlation between mobilization and accretion

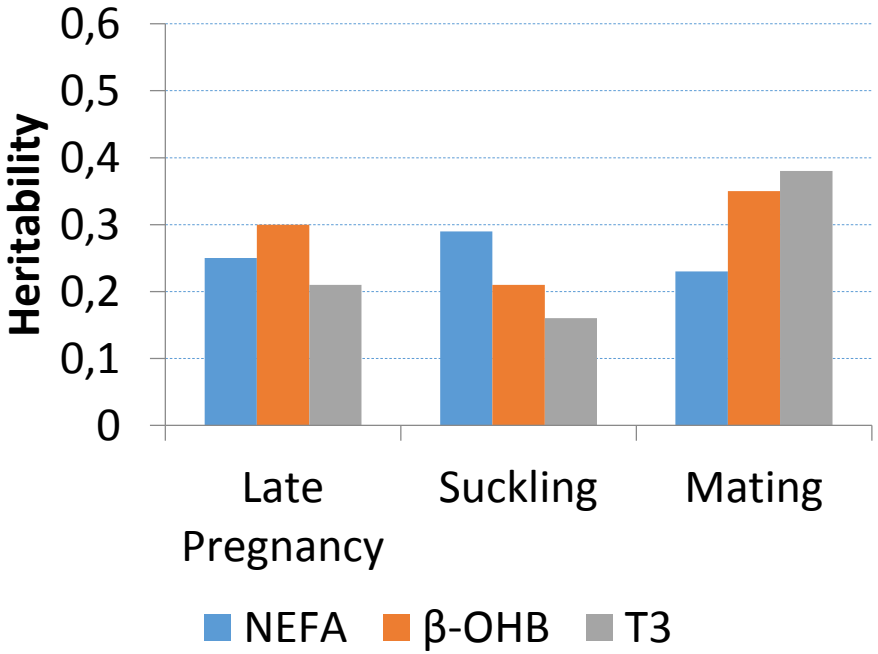
➔

	BW loss	BW gain
BCS loss	**0.9** (±0.31)	
BCS gain		**0.65** (±0.14)

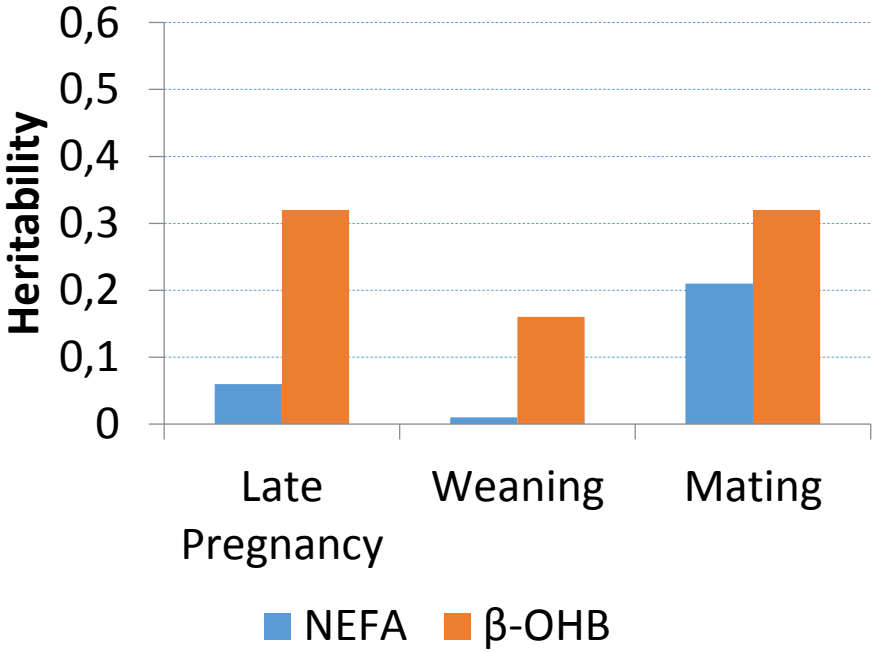
➔ BR mobilization (loss) and accretion (gain) processes are genetically linked.

Biomarkers for body reserves: genetic parameters

in Romane

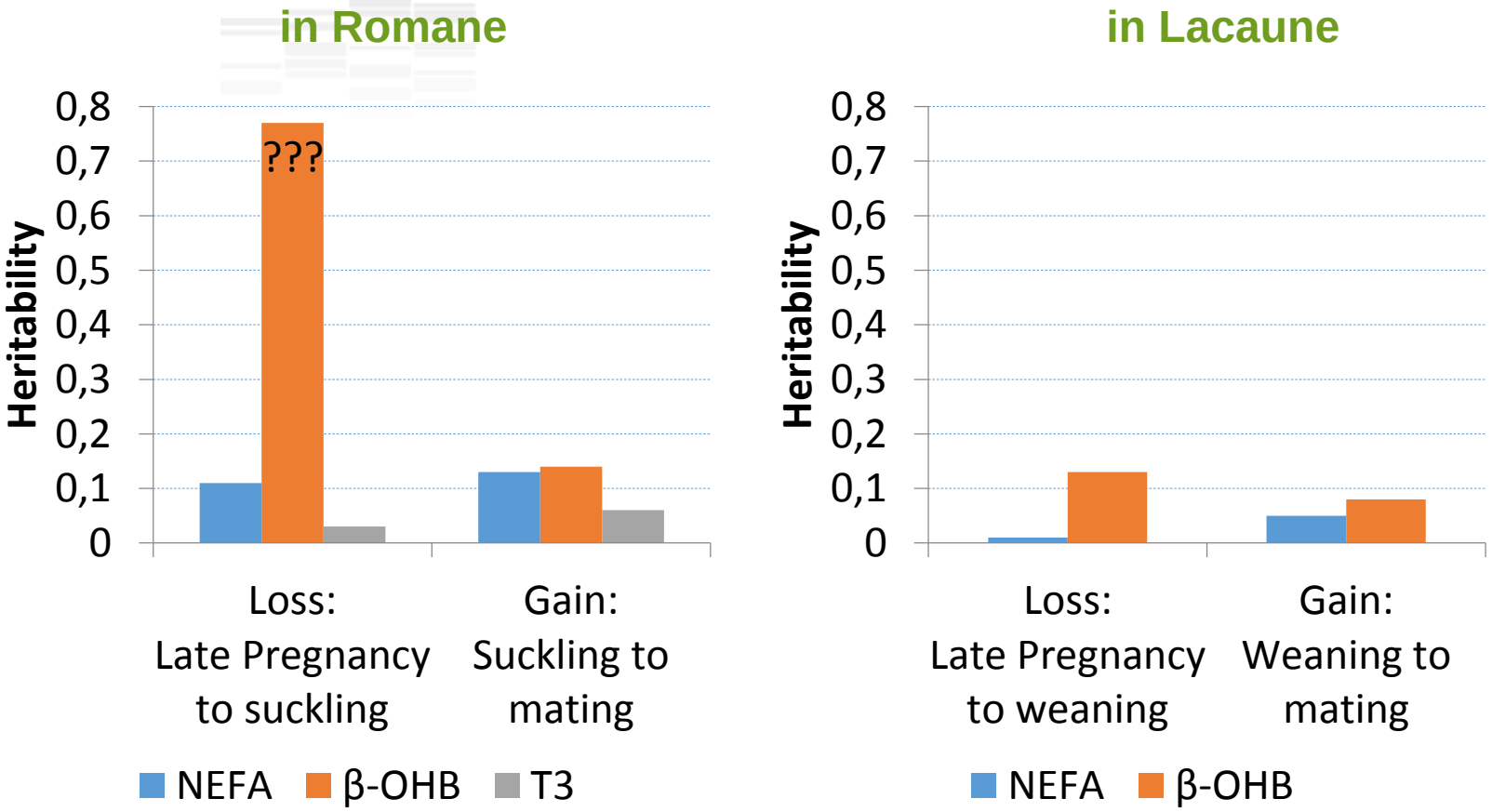


in Lacaune



➔ Levels in biomarkers of BR metabolism are heritable traits.

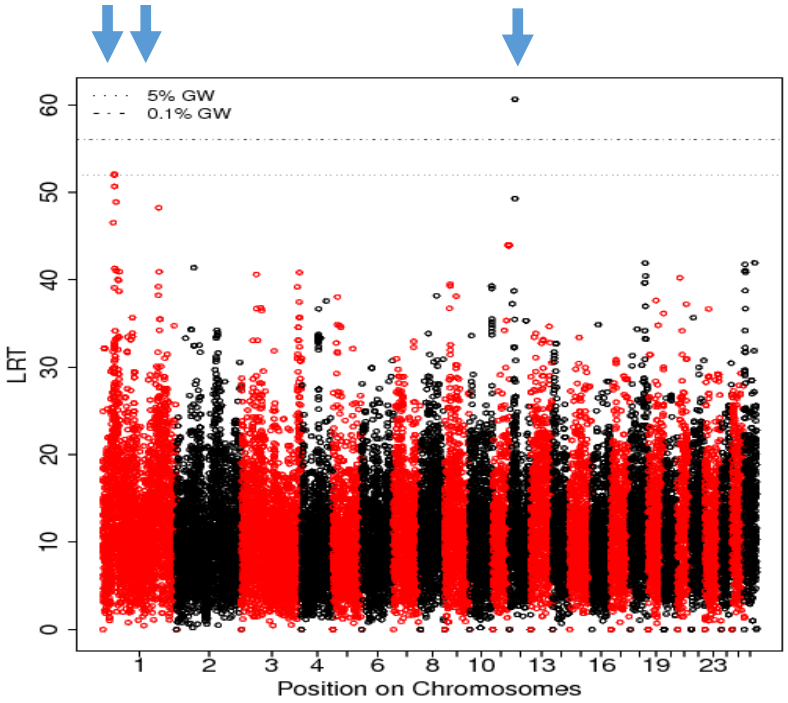
Biomarkers for body reserves: genetic parameters



➔ Changes over time in biomarkers are lowly heritable except β-OHB in meat sheep to be confirm.

Genomic analysis in Romane

➔ Several genomic regions associated with body reserves.



Trait	Chr.	Pos. Mb	Genes
BCS M/P/ L/W	1	44.73	DIRAS3…
	1	208.81	NAP1L1…
	12	19.22	LYPLAL1, TGFB2…

DIRAS3, GTP-binding protein Di-Ras3 ; NAP1L1, Nucleosome Assembly Protein 1 Like 1 ; LYPLAL1, lysophospholipase-like 1; TGFB2, Transforming growth factor-beta 2.

Biological functions: body composition, subcutaneous-to-visceral white adipose tissue ratio, adipogenesis regulation

➔ Two main regions associated with BCS on chromosomes 1 and 12.

Take Home Message :

- Body reserves successfully assessed with:
  - body condition score (and body weight)
  - metabolic biomarkers

- Body reserves dynamics:
  - alternation of mobilization and accretion processes throughout productive cycles
  - linked to physiological and environmental factors

- Levels and variations in body reserves:
  - are heritable traits (low to moderate heritabilities)
  - are associated with genomic regions

➔ **Genetic selection of sheep that better manage BR can be envisaged in future breeding programs to improve their resilience.**

Acknowledgments

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Thanks for your attention

Photo : INRA C. Maître

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Genetic approaches to improve sustainability and adapting to climate change (WP5)

→ novel phenotypes for improving animal resilience/adaptability :
The body reserves mobilization-accretion process

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Body reserves and production :

in Romane

Genetic correlations:

	Birth weight (litter or lamb)	Lamb growth or weaning weight
BCS	**NS to -0.3** (±0,10)	**NS to -0.35** (±0,10)
BCS loss	**-0.40** (±0,10)	NS
BCS gain (Early Pregnancy)	**0.34** (±0,16)	NS

➔ Higher level of production associated with lower BR level at mating and higher BCS loss during pregnancy and suckling in meat sheep.

in Lacaune

Genetic correlations:

	Milk	
BCS at mating	**-0.4 to -0.6** (±0,13)	
BCS loss	*-0.45 (±0,30)*	
BCS gain	**-0.6** (±0,13)	

➔ Higher level of production associated with lower BR level at mating and lower BCS gain before mating in dairy sheep.