How genetic selection could contribute to the multi performance of farming systems?

A modelling approach applied to Lacaune dairy sheep

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INRAE

Avec la contribution financière du compte d'affectation spéciale développement agricole et rural CASDAR

MINISTÈRE DE L'AGRICULTURE ET DE LA SOUVERAINETÉ ALIMENTAIRE
Liberté Égalité Fraternité

INSTITUT DE L'ELEVAGE idele

La responsabilité du ministère en charge de l'agriculture ne saurait être engagée

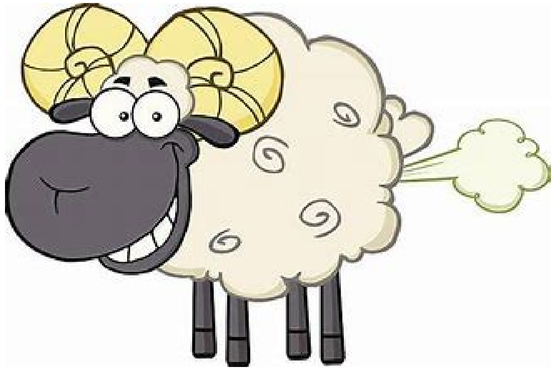
Multiperformance of farming systems

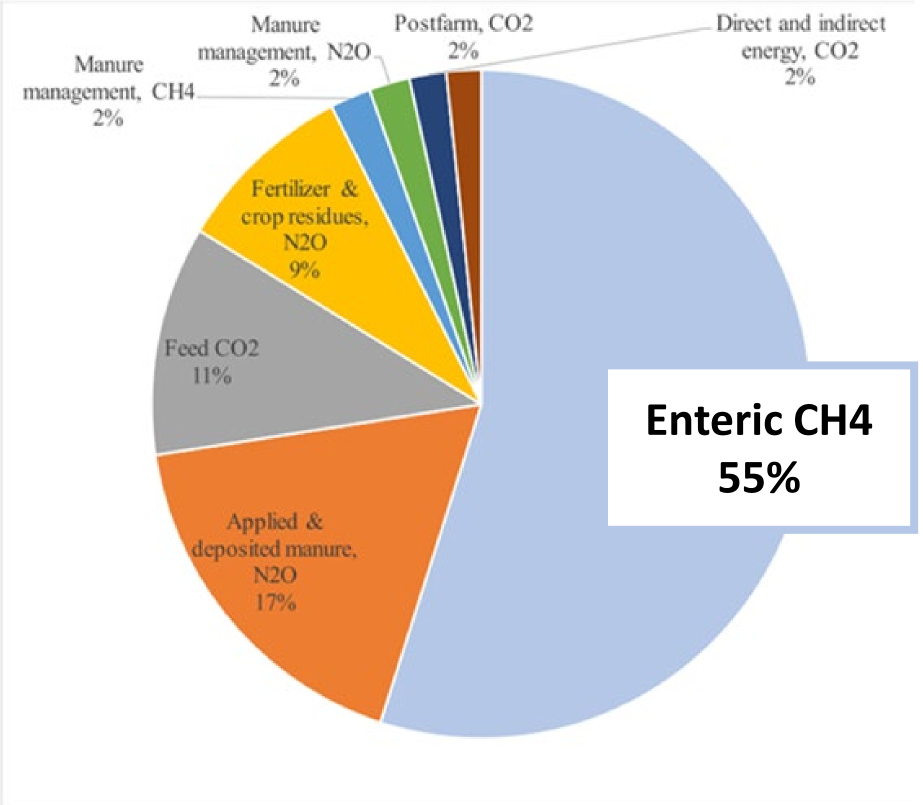
Sustainability (Clay et al. 2020

Economic efficiency

Social impact

Environmental impact





Global GHG emissions from small ruminant supply chains; adapted from Gerber et al. (2013).

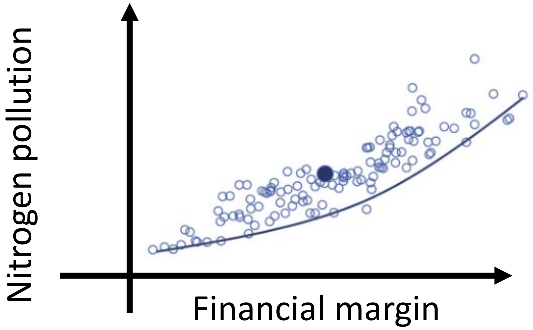
Improvement approaches

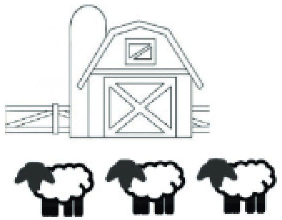
Multiperformance

Management practices
Farming system design
- Feed, reproduction

Selection practices
- Selecting traits that enhance both productivity and sustainability
- Operates at **population** levels
- Focusing on **long-term** changes

→ use of **individual-based models** to manage trade-offs at farm level





Ex : in dairy sheep
Villalba et al. 2019

?

Lacaune breed

Current breeding goal
- **Milk yield**
- **Milk composition**
- **Udder score**
- **Somatic cell score**

→ no selection ongoing for environmental performances (e.g. CH4)

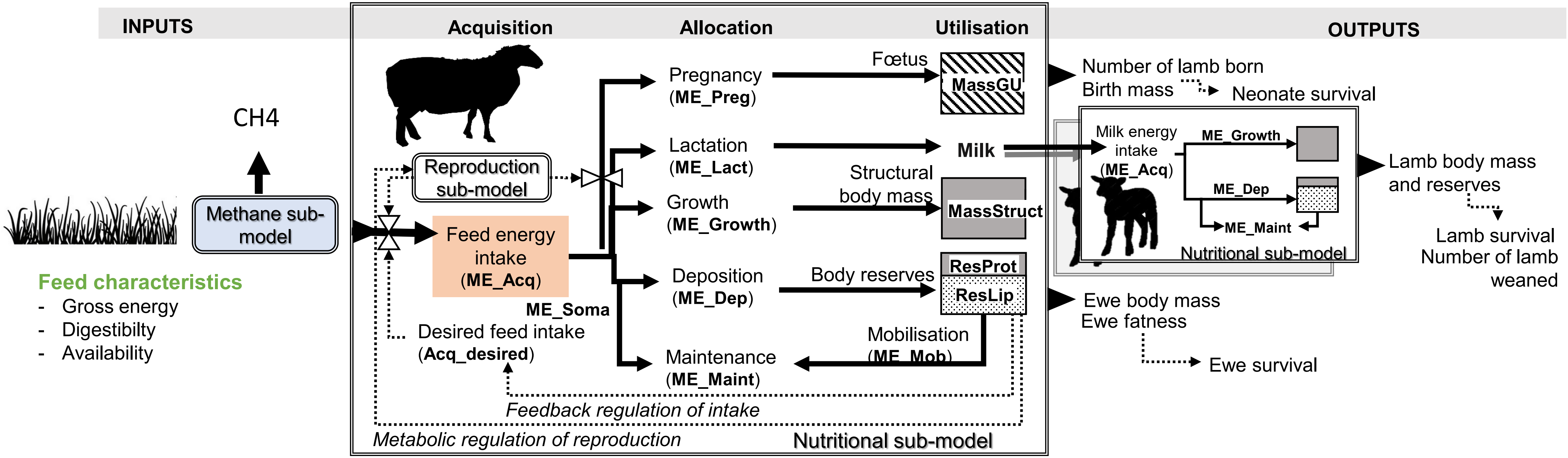
Approach of this study

Individual-based modelling to predict responses to variation in production environments and to selection
→ trade-offs at the individual level based on resource allocation theory

Examples:
Dairy goats: *Douhard et al. 2014*
Dairy cows: *Puillet et al. 2016, 2021*; *Bouquet et al. 2024*

Aim: Simulate phenotypic variability of the output traits using an individual-based model of dairy sheep

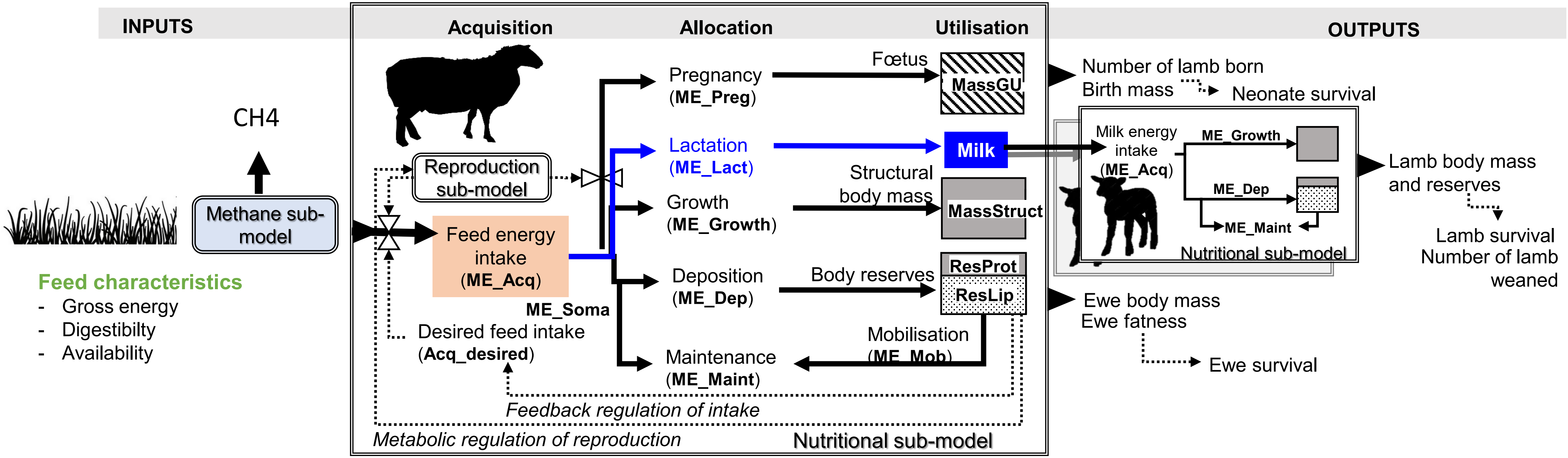
Sheep model



Metabolizable energy intake (ME_Acq)

= Feed gross energy − Gaseous energy (CH4) − Urinary energy − Fecal energy

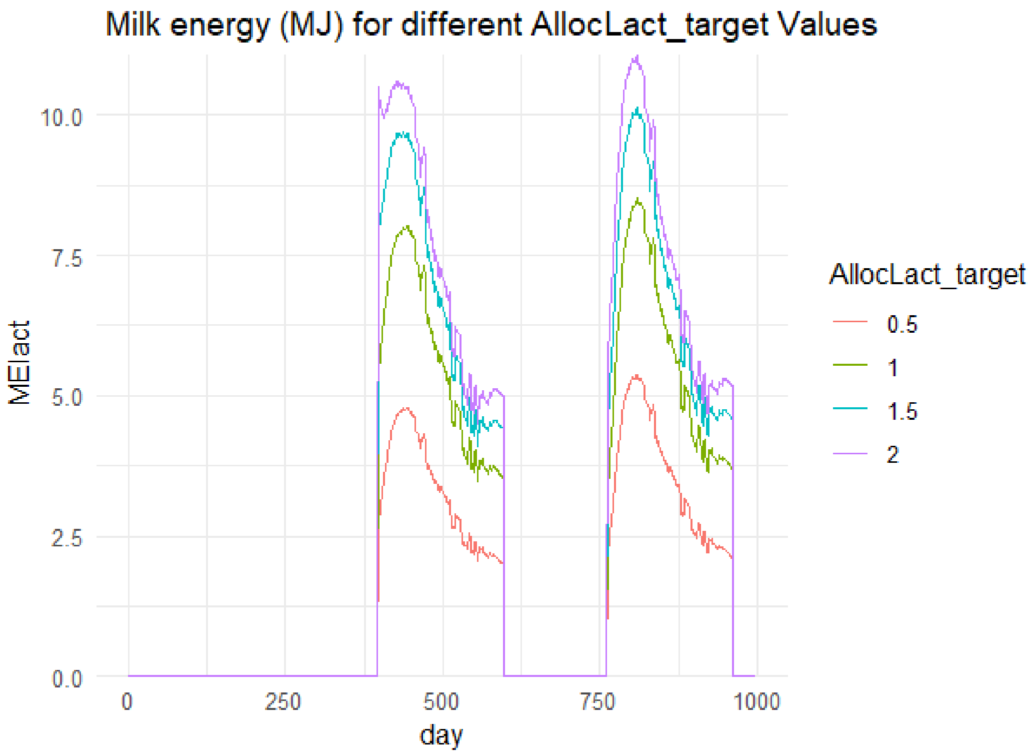
Focus 1: simulation of individual variability

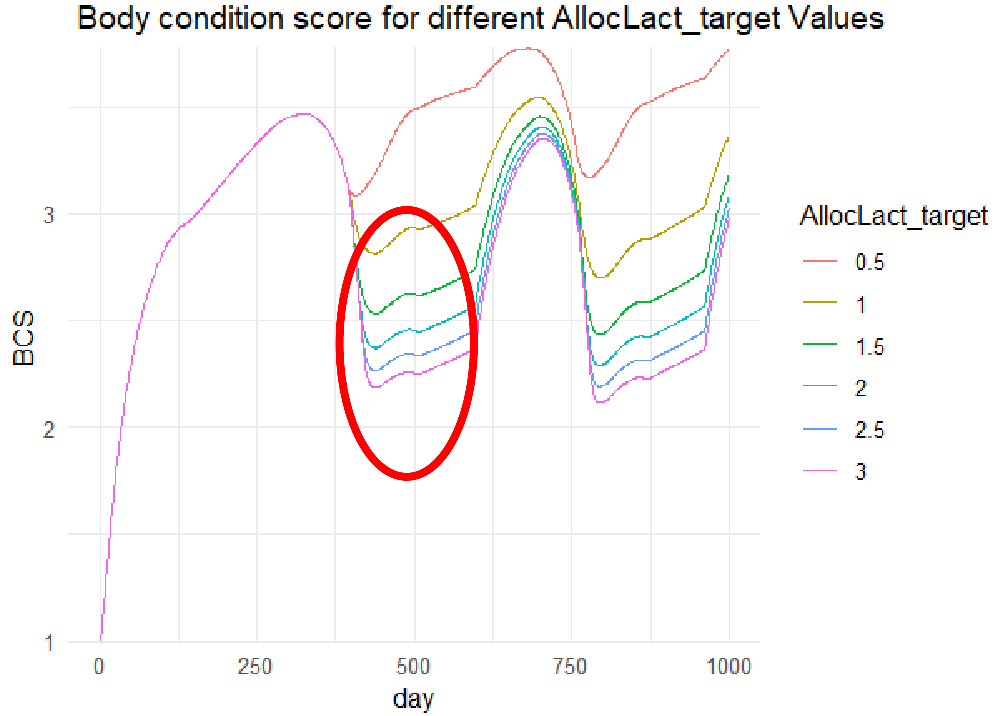


example : $\mathbf{ME_{Lact} = ME_{Acq} * AllocLact}$

with $\mathbf{AllocLact = AllocLact_{target} * \mathit{f(Lact\_time)}}$

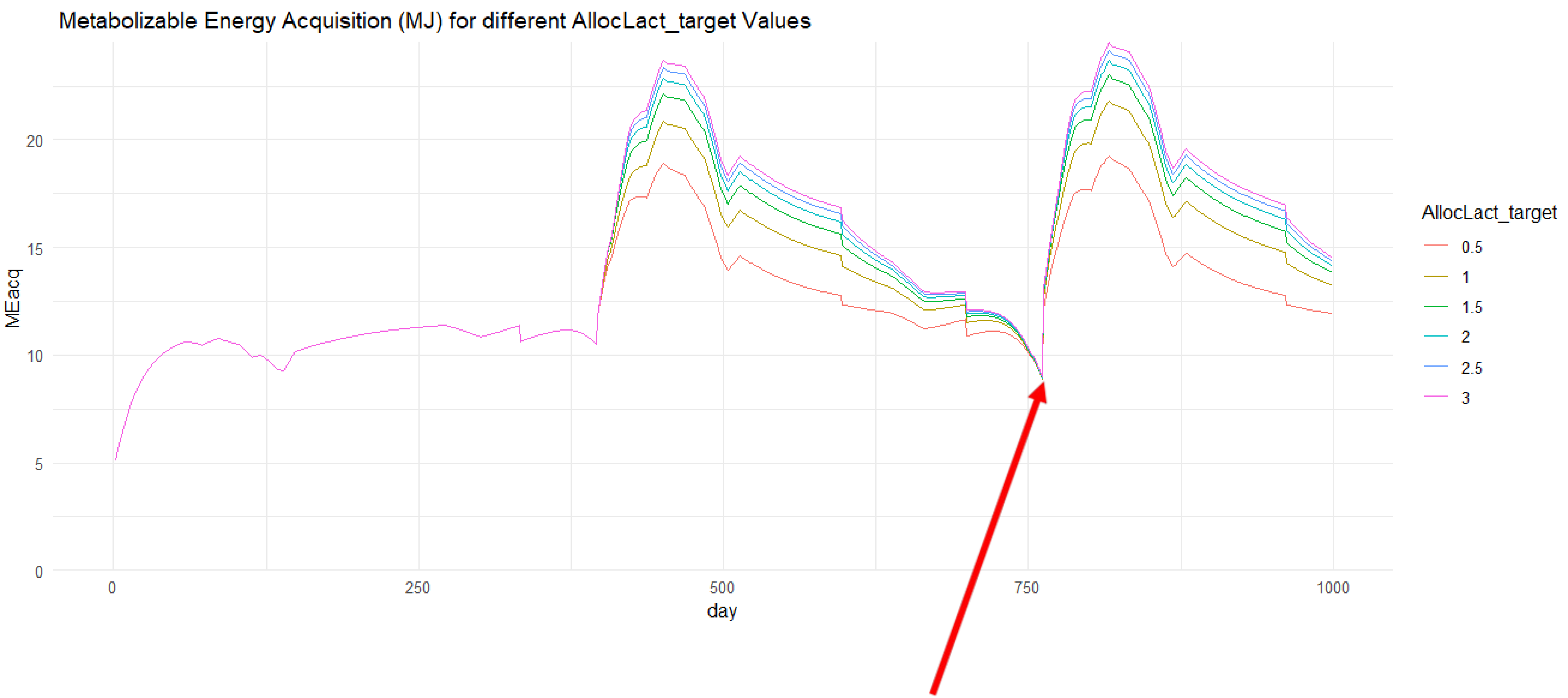
Focus 1: simulation of individual variability





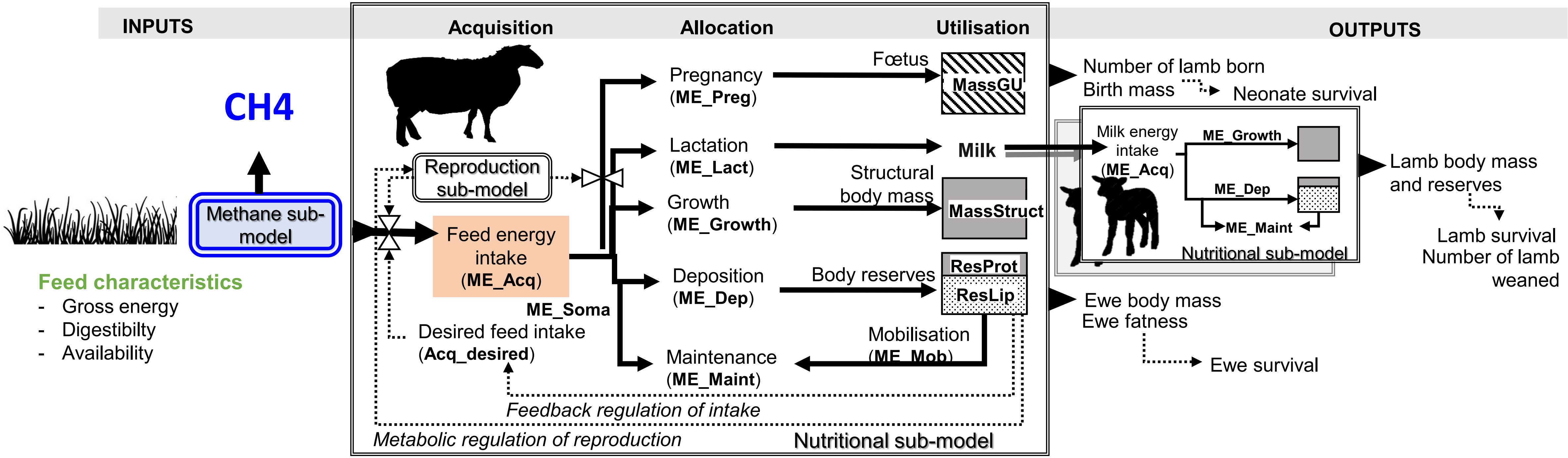
→ ***AllocLact**$_{target}$* can mediate a trade off among individuals between milk and BCS

Focus 1: simulation of individual variability



Reduction of ewe intake at the end of gestation when the gravid uterus mass is high (*Wilkinson and Chestnutt 1988*)

Focus 2: predict enteric CH4 emissions



Metabolizable energy intake (ME_Acq)

= Feed gross energy − **Gaseous energy (CH4)** − Urinary energy − Fecal energy

Focus 2: Predict enteric CH4 emissions

$$\mathbf{CH4} = \mathbf{DOM} \times \left(\mathbf{45.42} - \mathbf{6.66} \cdot \left(\frac{\mathbf{Feed\ Intake}}{\mathbf{Bodyweight}}\right) + \mathbf{0.75}\left(\frac{\mathbf{Feed\ Intake}}{\mathbf{Bodyweight}}\right)^{\mathbf{2}} + \right.$$

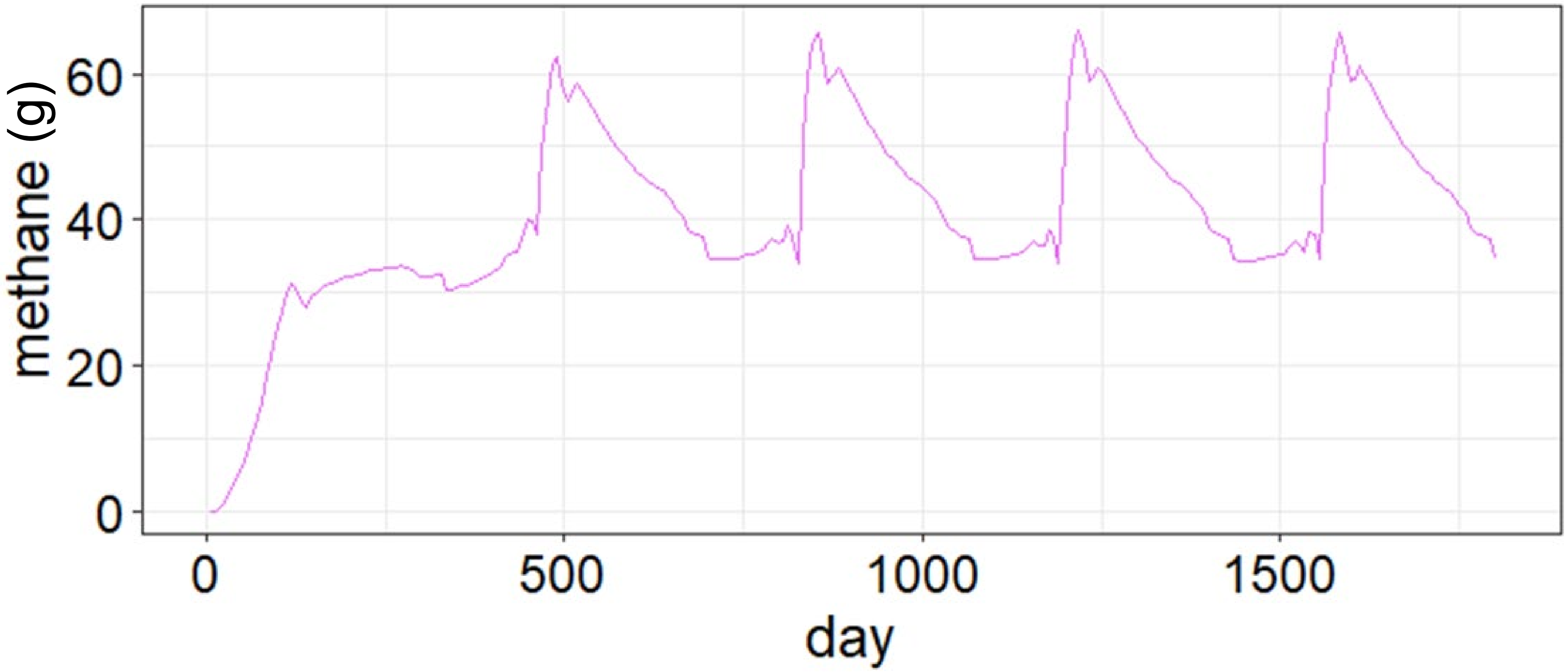
$$\left. \mathbf{19.65} \cdot \mathbf{PCO} - \mathbf{35.0} \cdot \mathbf{PCO^2} - \mathbf{2.69} \cdot \left(\frac{\mathbf{Feed\ Intake}}{\mathbf{Bodyweight}}\right) \cdot \mathbf{PCO}\right)$$

Feed characteristics:

- Digestible organic matter
- Proportion of concentrate in feed

Sauvant et al. 2011

Focus 2: Predict enteric CH4 emissions



→ **Within-individual changes in enteric CH4 emissions can be predicted**

Conclusions & the next steps

Multiperformance

(1) Individual variability

→ Estimate variance of coefficients using real data in Lacaune dairy sheep

→ Include a genetic component

Example : ***h^2 AllocLact$_{target}$***

Bouquet et al. 2024

(2) Prediction of CH4 emissions

→ Simulate individual variability in CH4 and potential trade-offs with production traits

→ Carbon footprint at the farm level

→ An approach to explore how genetic selection could contribute to the multi performance of farming systems