Exploring potential G x E interactions in the lifetime performance of suckling ewes

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Background

- Selective breeding is often based on animal performance evaluated in favorable feed environments where they can express their genetic potential
- Ranking might change in the presence of **genotype by environment (G x E) interaction**, especially in grazing systems where resources are seasonally limited and fluctuating
- G x E might result from **resource allocation trade-offs**: feed resources allocated to one body function cannot be used for other functions (Beilharz and Nitter 1998)
- **Ewe-lamb trade-offs** might determine ewe **lifetime performance**: potential negative relationships between lamb production (ex: prolificacy, growth) and ewe survival (ex: body reserves, longevity)

Material and methods

- Development of a **mechanistic model** of **energy allocation** between the ewe and her lamb to model ewe-lamb trade-offs and their effect on ewe lifetime performance depending on the feed environment (Fig. 1)
- Simulation of **individual variation** in 22 model parameters controlling acquisition (feed intake) and allocation to biological functions (growth, maintenance, pregnancy and lactation)
- 1 combination of parameter levels = 1 genotype
- N = **2,760 genotypes** simulated (Morris' Elementary Effects Screening Method design to well cover the parameter space)
- Each genotype simulated in **favorable** and **unfavorable environment** (Fig. 2)

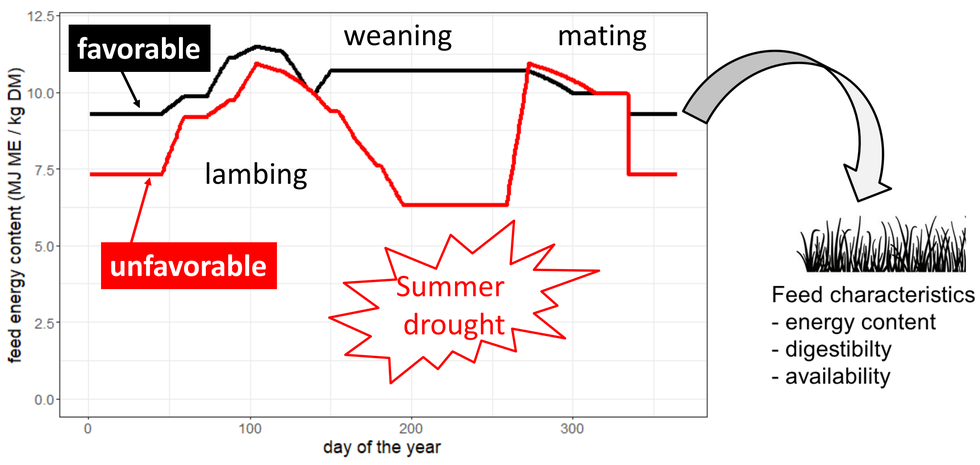

Fig. 2. Annual environment scenarios of feed energy content

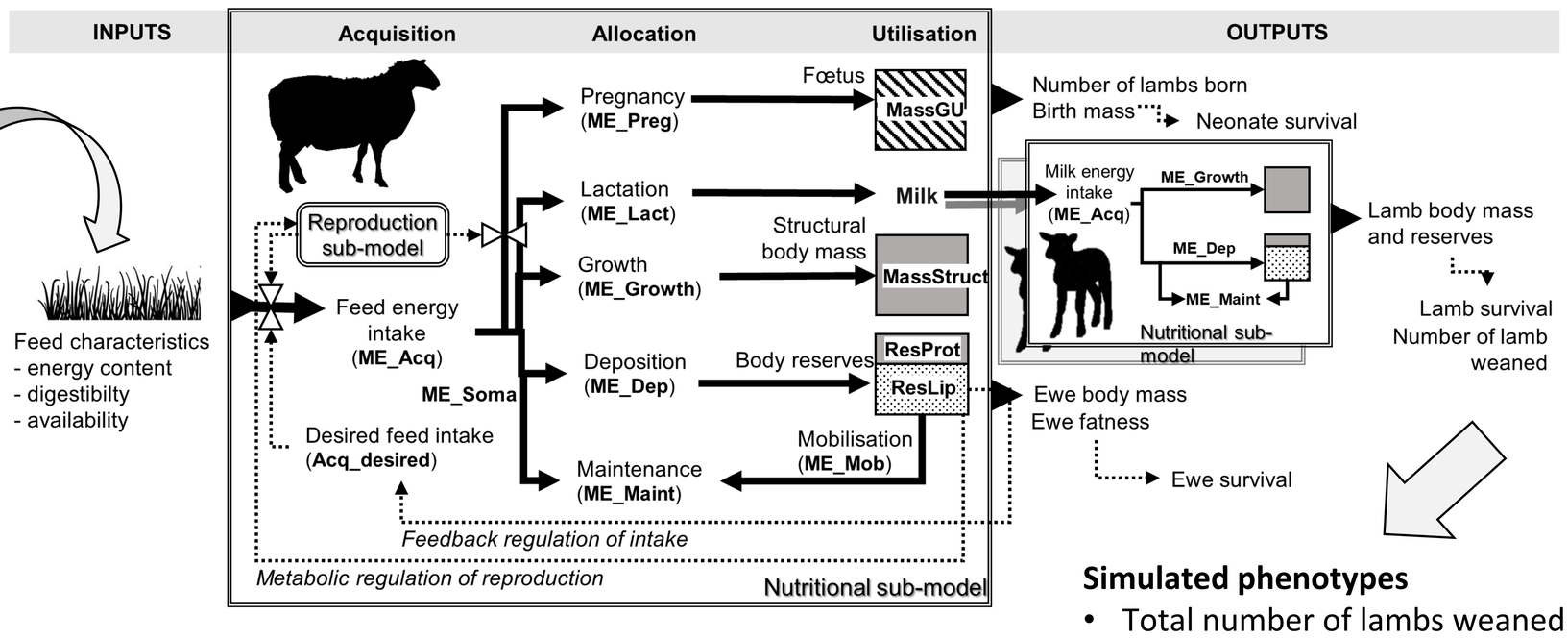

Fig. 1. Conceptual model of ewe-lamb model of energy allocation

Simulated phenotypes

- Total number of lambs weaned per ewe (**TNLW**)
- Parities per ewe (longevity)
- Litter size born
- Neonate survival
- Postnatal lamb survival

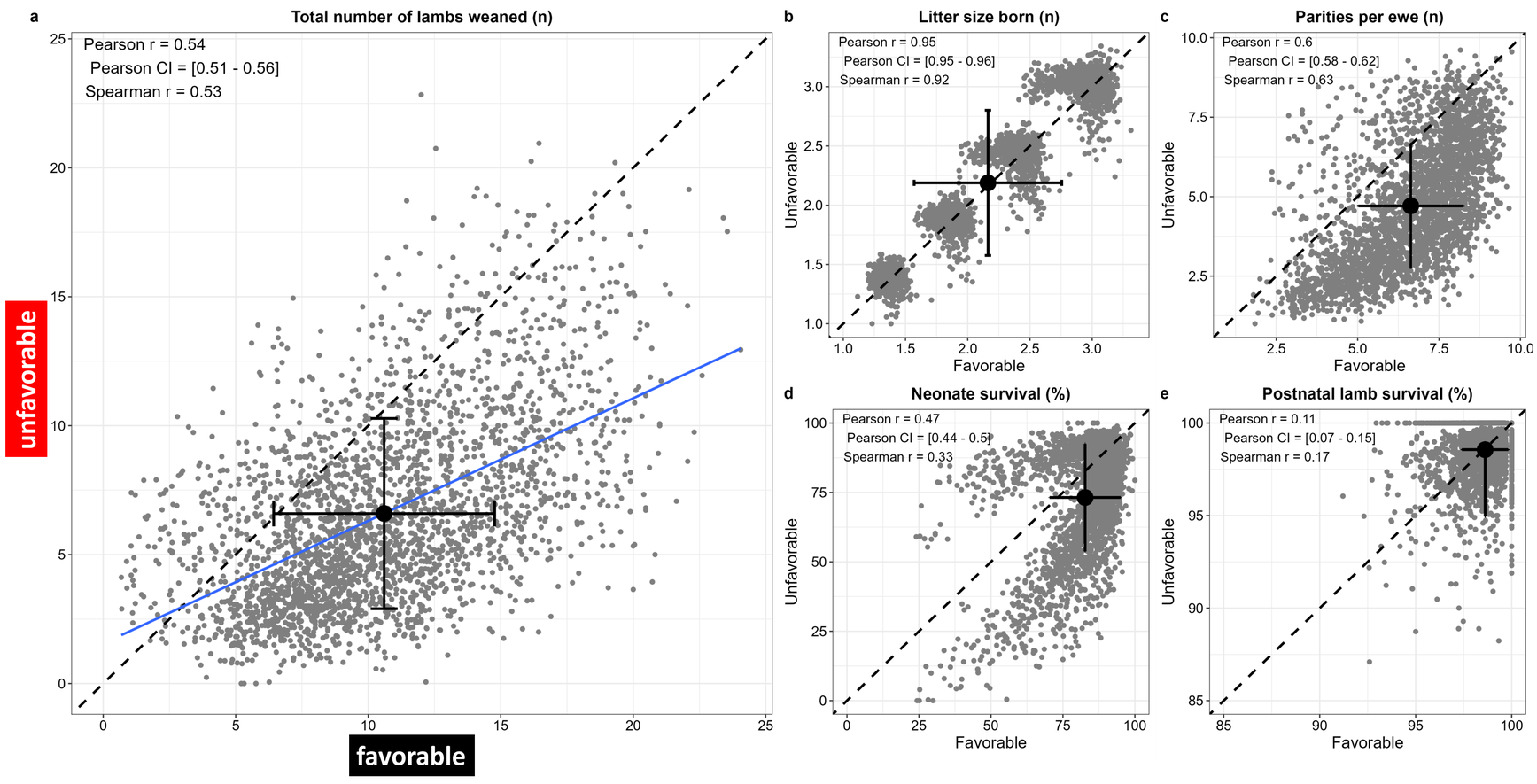

Fig. 3. Simulated phenotypes of the ewe-lamb model of energy allocation. Each grey point = 1 genotype. Black point with error bars = mean performance and confidence intervals

Results

- Decrease of lifetime performance (TNLW) in the unfavorable scenario (6.59 ± 3.69 vs. 10.60 ± 4.17). Mainly due to reduction in:
  - Neonate survival (73.2% ± 19.3 vs. 82.7% ± 12.3 in favorable)
  - Ewe longevity (4.71 parities ± 1.94 vs. 6.63 ± 1.61 in favorable)
- **Support for G x E** indicated by low to moderate correlations between environments:
  - TLNW: 0.53 (Fig. 3A)
  - Longevity: 0.63 (Fig. 3C)
  - Neonate survival: 0.33 (Fig. 3D)
- The most influential input parameter for TNLW:
  - Prolificacy potential in favorable
  - Target fat reserve proportion in unfavorable environment

Conclusion

- Ewe life performance is based on **multiple components** (ewe longevity × litter size × neonatal survival × postnatal survival) whose relative importance depends on the environment
- **Ewe-lamb resource allocation trade-offs** can be a **key determinant of G x E**: good ewes balanced the available energy between their own needs and their lambs. e.g., too high litter size increased the lamb neonatal mortality due to too low birth mass
- Future model applications will be to simulate populations under selection and explore different breeding objectives to improve sheep robustness

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