Genotype by environment interaction and response to selection for milk production traits in Lacaune sheep

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Background

- Improving dairy sheep milk production →
  - Desirable breeding goal
  - Farm profitability
- Genetic evaluation combining data from animals reared in different countries →
  - Selection intensity increase → increased genetic gain
- Lacaune sheep in Greece and France

Important to identify

- Genotype by environment (G×E) interaction
- Response to selection (genetic gain) based on joint genetic evaluations

Objectives

(i) To investigate **genotype by environment interaction (G×E)** for **milk yield and composition** in purebred **Lacaune sheep** reared in **Greece and France**

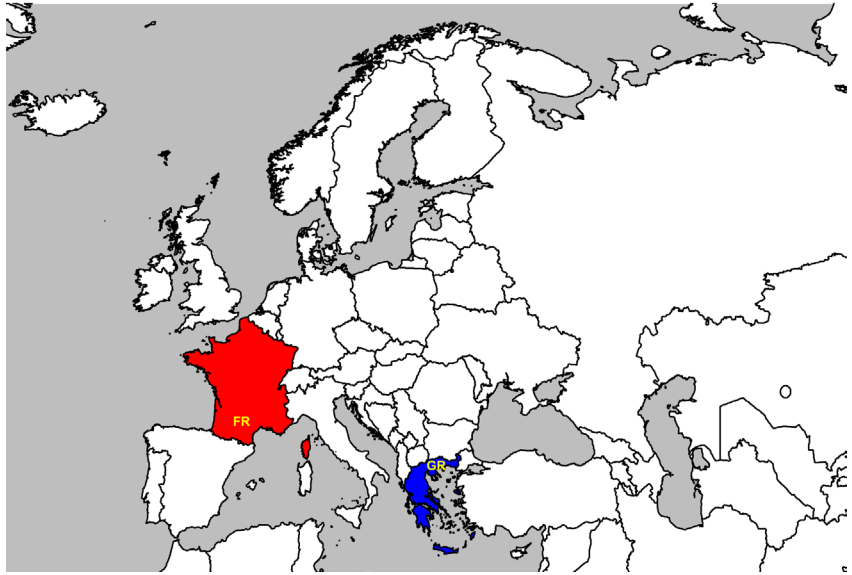
(ii) To compare potential **genetic gain** from selection **across and within countries**

Materials and Methods

Animals and Farms

- **Greece**
  - 4 intensive farms
  - 1,658 Lacaune ewes
  - 1st-2nd lactation period
  - Born after AI from imported Lacaune rams (n=14)
- **France**
  - 186 semi-extensive farms
  - 4,859 Lacaune ewes
  - 1st-7th lactation period
  - **Related to ewes in Greece**

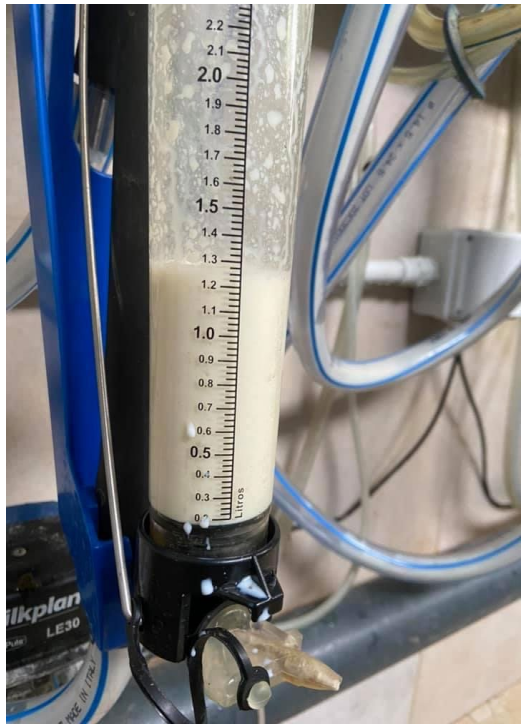
    (6 common sires & 11 grandsires)



Materials and Methods

Phenotypes

- Individual monthly records
  - Milk yield
    - ✓5-6 measurements
  - Milk composition
    - ✓~3 samples in mid lactation
    - ✓Fat & Protein content
- Milking period records
  - Milk yield → Fleishmann method
  - Milk composition → average of individual monthly records weighted for milk yield



Materials and Methods

Datasets

Characteristic	Greece	France
Study period	2021-2022	2019-2022
Number of ewes	1,658	4,859
Number of sires	14	64
Number of records	1,658	7,166
Type of records	Single	Multiple
Number of first parity records	858	4,047
Number of third and above parity records	0	555
Milking period length (days, SD)	**168.7 (17.72)**	**168.8 (38.94)**
Age at lambing (months, SD)	20.4 (6.00)	20.5 (10.65)
Days from lambing to first sampling (SD)	34.2 (6.66)	51.5 (11.82)

Materials and Methods

Data analysis – Genetic parameter estimation

- Mixed linear models – REML method
  - Fixed effects → farm, year, parity, milking period length, days from lambing, combination of test days
  - Random effects → additive genetic (pedigree with 26,547 animals) & permanent environmental (French data → repeated records)
- Variance components and genetic parameters
  - Univariate analyses
  - Approximate genetic correlations using common sire & grandsire EBVs

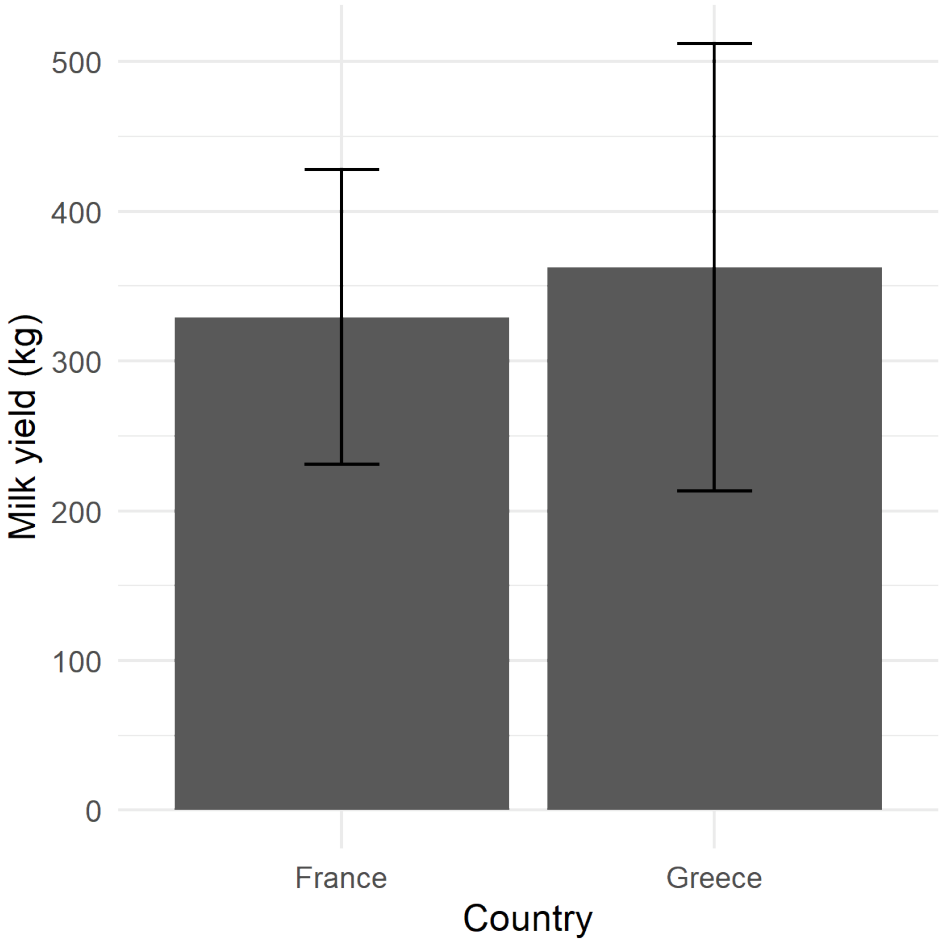
Materials and Methods

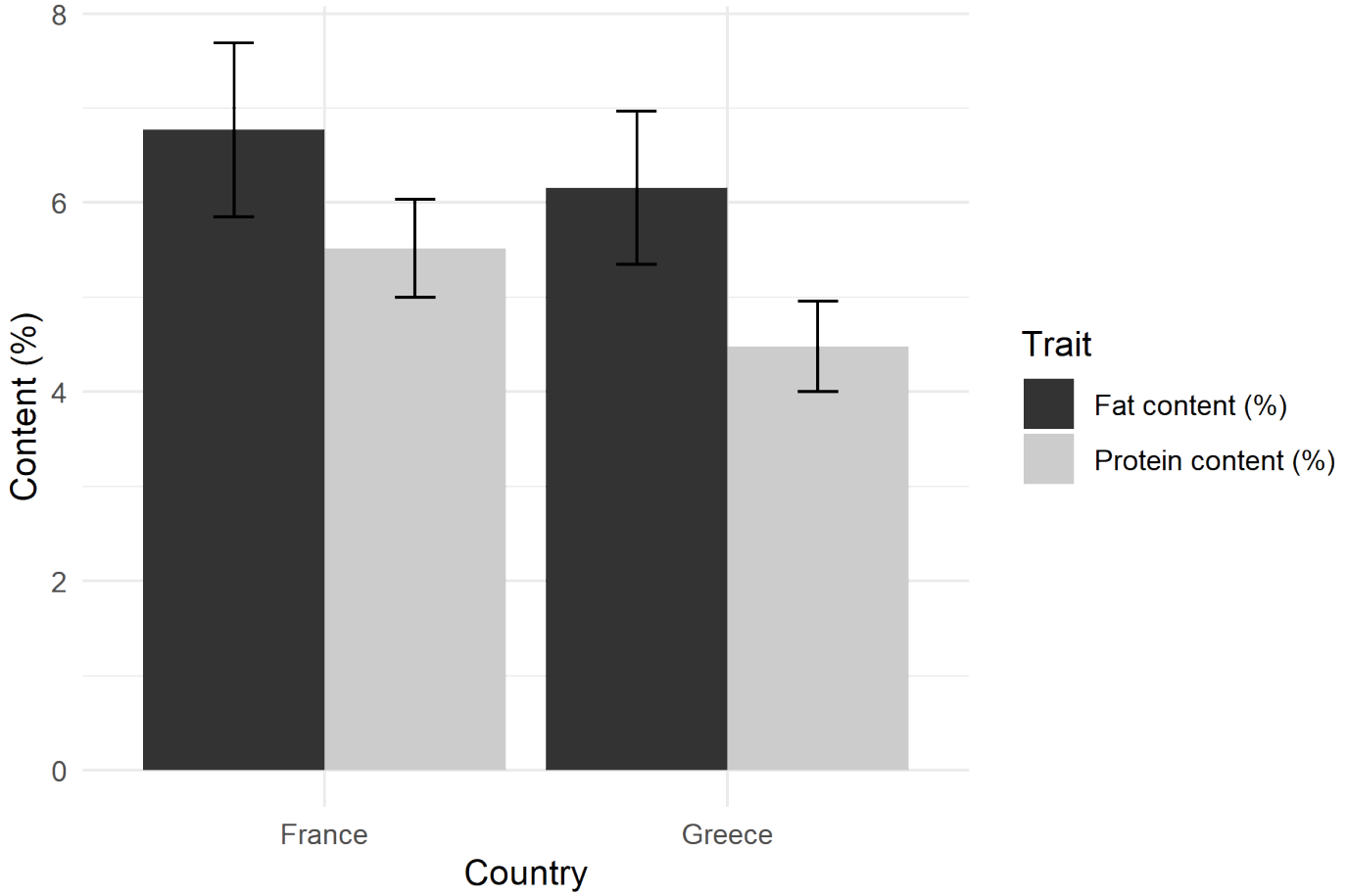
Data analysis – Response to selection

- $\Delta G = i \times r \times \sigma_A$
  - Selection candidates in Greece (n=30) & France (n=600)
  - Selection intensities (i) → Top 10 and 15 sires within & across country
  - Accuracy of selection (r) → Square root of sire EBV reliability
  - Additive genetic standard deviation (σ_A) → Square root of additive genetic variance for each trait and country

Results

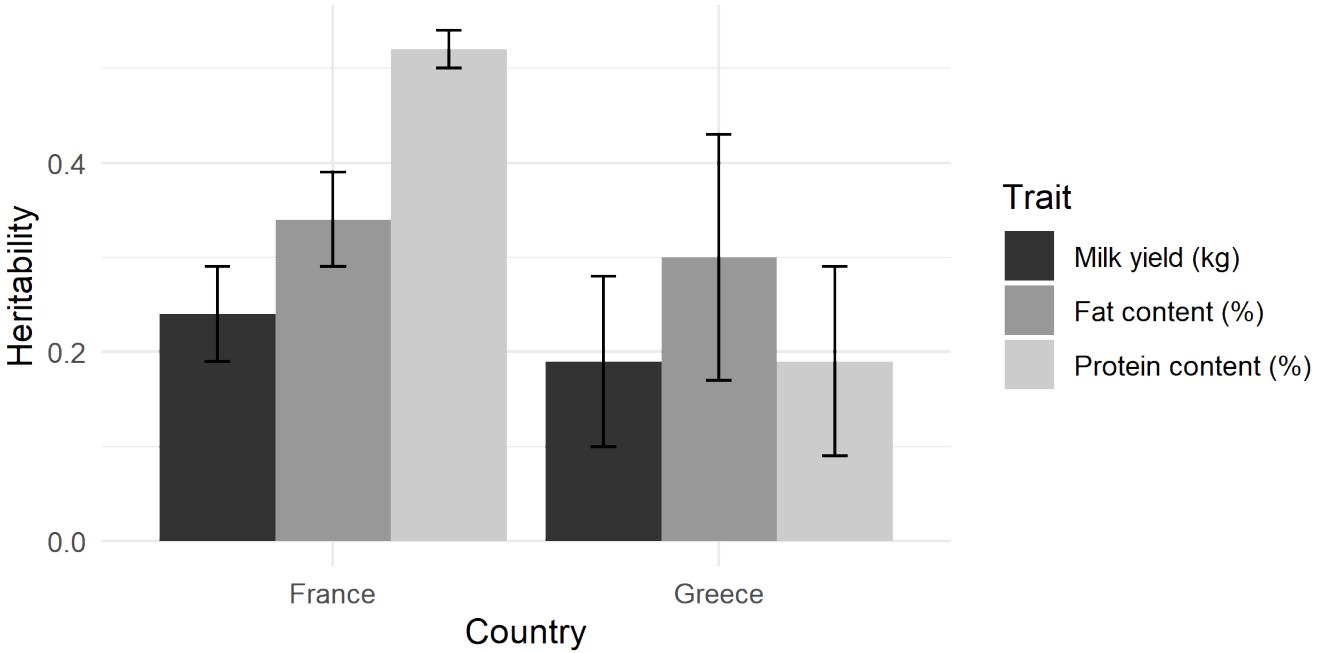
Descriptives

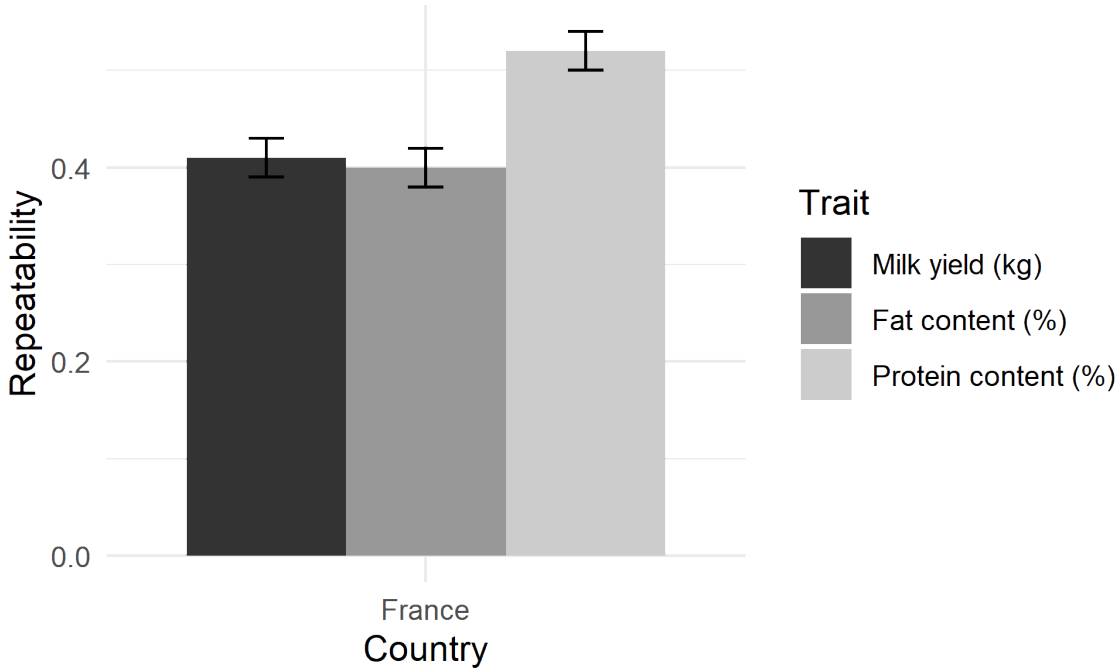




Results

Heritability & Repeatability





Results

Genetic correlations - G×E

	Milk yield (kg) – GR	Fat content (%) – GR	Protein content (%) – GR
Milk yield (kg) – FR	0.86 (0.13)*		
Fat content (%) – FR		0.57 (0.21)*	
Protein content (%) – FR			0.88 (0.13)*

*Indicates statistically significant estimates (P<0.05)

Results

Response to selection – Milk yield

Selection scenario	Top sires	N sires	PS%	i	r	σ_A	ΔG	ΔG%
Within Greece	10	30	33.3	1.07	0.84	42.05	**37.62**	**45.78**
Within Greece	15	30	50.0	0.78	0.84	42.05	**27.56**	**35.57**
Within France	10	600	1.7	2.46	0.81	26.60	**53.18**	**99.89**
Within France	15	600	2.5	2.32	0.81	26.60	**50.22**	**100**
Across Greece	10	630	1.6	2.48	0.79	42.05	**82.80**	**100**
Across Greece	15	630	2.4	2.34	0.79	42.05	**77.47**	**100**
Across France	10	630	1.6	2.48	0.81	26.60	**53.24**	**100**
Across France	15	630	2.4	2.34	0.81	26.60	**50.18**	**100**

PS=proportion selected, i=selection intensity, r=accuracy of selection, σ_A=genetic standard deviation of trait, ΔG=response to selection, ΔG%=percentage of genetic gain from genetic evaluation within compared to across countries

Results

Response to selection – Fat content

Selection scenario	Top sires	N sires	PS%	i	r	σ_A	ΔG	ΔG%
Within Greece	10	30	33.3	1.07	0.88	0.41	**0.38**	**50.16**
Within Greece	15	30	50.0	0.78	0.88	0.41	**0.28**	**39.98**
Within France	10	600	1.7	2.46	0.84	0.46	**0.95**	**100**
Within France	15	600	2.5	2.32	0.84	0.46	**0.90**	**100**
Across Greece	10	630	1.6	2.48	0.75	0.41	**0.76**	**100**
Across Greece	15	630	2.4	2.34	0.75	0.41	**0.72**	**100**
Across France	10	630	1.6	2.48	0.79	0.46	**0.91**	**100**
Across France	15	630	2.4	2.34	0.79	0.46	**0.86**	**100**

PS=proportion selected, i=selection intensity, r=accuracy of selection, σ_A=genetic standard deviation of trait, ΔG=response to selection, ΔG%=percentage of genetic gain from genetic evaluation within compared to across countries

Results

Response to selection – Protein content

Selection scenario	Top sires	N sires	PS%	i	r	σ_A	ΔG	ΔG%
Within Greece	10	30	33.3	1.07	0.74	0.05	**0.04**	**40.96**
Within Greece	15	30	50.0	0.78	0.74	0.05	**0.03**	**31.83**
Within France	10	600	1.7	2.46	0.84	0.30	**0.63**	**99.83**
Within France	15	600	2.5	2.32	0.84	0.30	**0.59**	**100**
Across Greece	10	630	1.6	2.48	0.77	0.05	**0.09**	**100**
Across Greece	15	630	2.4	2.34	0.77	0.05	**0.08**	**100**
Across France	10	630	1.6	2.48	0.84	0.30	**0.63**	**100**
Across France	15	630	2.4	2.34	0.84	0.30	**0.59**	**100**

PS=proportion selected, i=selection intensity, r=accuracy of selection, σ_A=genetic standard deviation of trait, ΔG=response to selection, ΔG%=percentage of genetic gain from genetic evaluation within compared to across countries

Conclusions

- **G×E interaction**
  - ***Milk yield and protein content*** → *Strong genetic correlations between the two counties* → ***no presence of G×E interaction***
  - ***Fat content*** → *Moderate genetic correlations between the two countries* → *some degree of* ***sire re-ranking***
  - *Joint genetic evaluation of Lacaune sheep in Greece and France* → ***Feasible***
- **Response to selection (genetic gain)**
  - *Sire selection across countries based on joint genetic evaluation* → ***genetic gain increase for studied traits in both countries***
  - *Greece will benefit more (increase by 68.17%) compared to France (increase by 0.16%)*

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