Phenotyping and selecting for genetic resistance to gastro-intestinal parasites in sheep: the case of the Manech French dairy sheep breed

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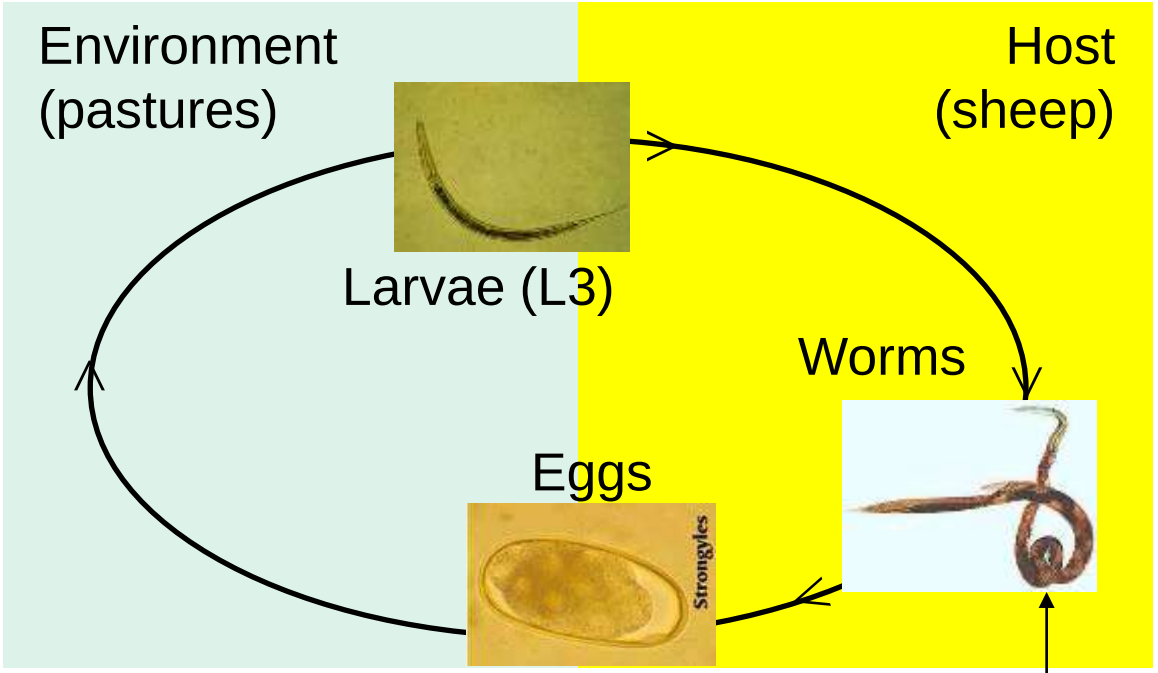
The Blond-Faced Manech dairy sheep breed

Basque country (south-west of France) : rainy and mountainous area, favorable to gastrointestinal nematodes

280,000 Blond-Faced Manech.
Efficient breeding program conducted by CDEO
- -28% ewes in selection program
- -150 AI progeny-tested rams / year

The gastrointestinal nematodes (NGI) parasites in sheep

Life cycle



Abomasum	Haemonchus contortus Teladorsagia circumcincta
Small intestine	Trichostrongylus colubriformis

Why selecting for resistance to NGI parasites ?

- **Economic** concern
  - ✓ Economic losses due to decrease of production and culling
  - ✓ Cost of the anthelminthic treatment

- Increasing **resistance to anthelmintic** molecules
  - ✓ No more effects of molecules in numerous flocks (especially in the Blond-Faced Manech flocks)

- **Environment** concern
  - ✓ Ecotoxicity => pollution of soil, entomofauna sensitive to chemical residues

Genetic selection = sustainable and efficient alternative to treatments ?

How to measure resistance to NGI parasites ?

Host **resistance** => decrease establishment, development, fecundity and fitness of the worms

FEC | Faecal Egg Count (eggs per gram) from coproscopy = reference method

Also : **resilience** => maintain performance while subjected to parasite challenge.

Measure of packed cell volume (PCV)

How to measure resistance to NGI parasites ?

- Natural infestation on pasture
  - ✓ In many countries (Oceania, UK)
  - ✓ But : depends on meteorological conditions ; no control of species and larvae ingested

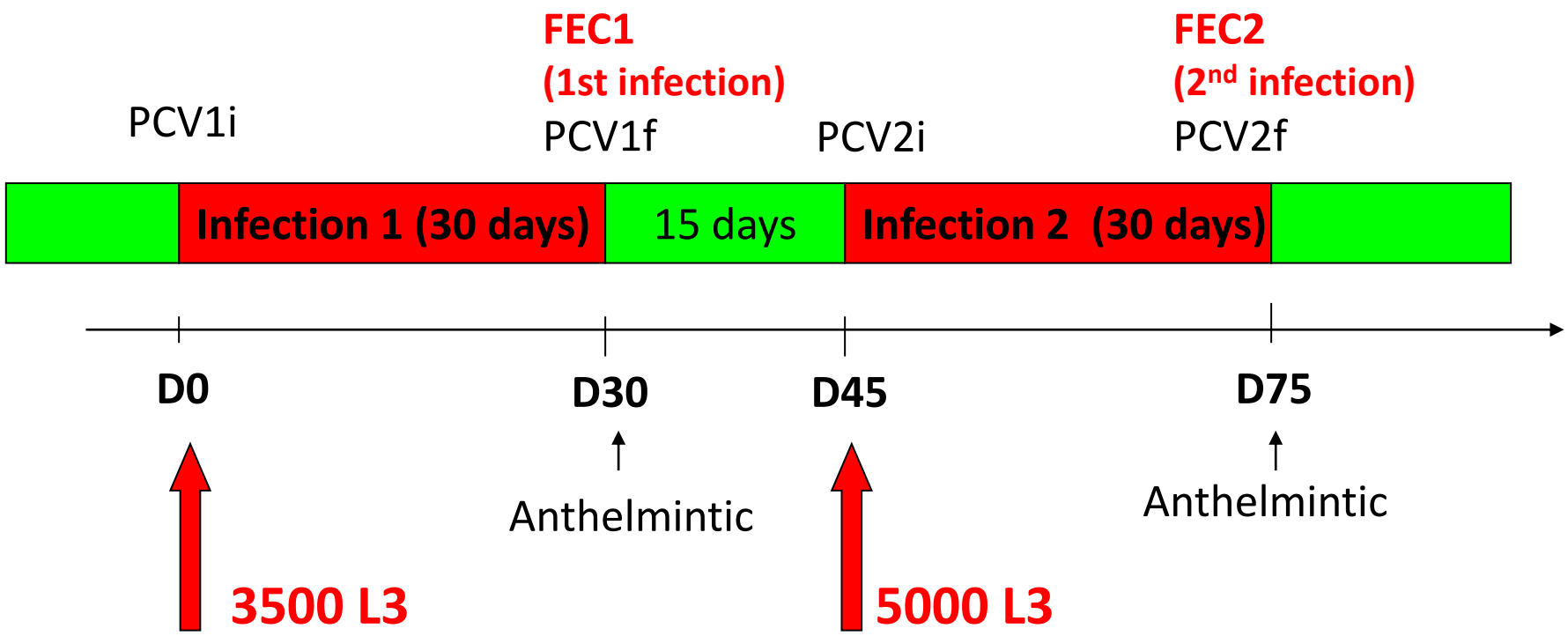
- **Experimental infestation**
  - ✓ Original design set up in France (Jacquiet at al, 2015)
  - ✓ Applied to young rams gathered in breeding centers
  - ✓ Future sires
  - ✓ Enabled by collective breeding programs
  - ✓ Rams must be naïve regarding gastrointestinal parasites

Protocol of experimental infections (*Haemonchus contortus*)

Source Jacquiet

Two periods of infection (duration = 1 month)

FEC in eggs / gram
PCV in %



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What is the relevance of an experimental infection ?

- High correlation between resistance in **experimental infestation vs natural infestation** (~ 0.8 to 0.9)
- High correlation between resistance to **Haemonchus contortus *vs* other species** of nematodes (~ 1 | Gruner *et al.* 2004)
- Correlation between resistance of **young rams in breeding center and offspring on pastures** is being assessed (on-going on-farm experiments using divergent lines of rams)
- Resilience (packed cell volume) => allows to check that rams have no pathologic effects

Experimental infections in Manech Blond-Faced

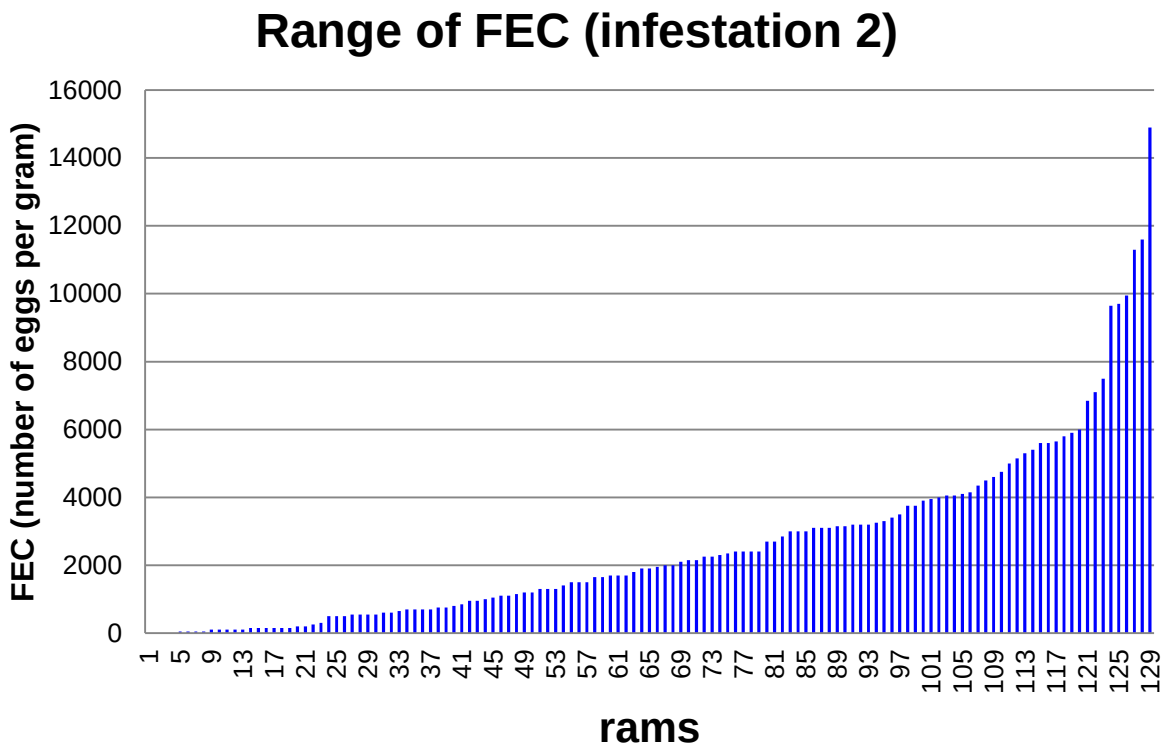
5 experimental infestations design carried out from 2008 to 2015

451 rams, mainly aged 2 or 3

	FEC1	FEC2	PCV1f-PCV1i	PCV2f-PCV2i
Mean	2141	1641	3.4	1.0
Std	2491	1787	3.75	3.15

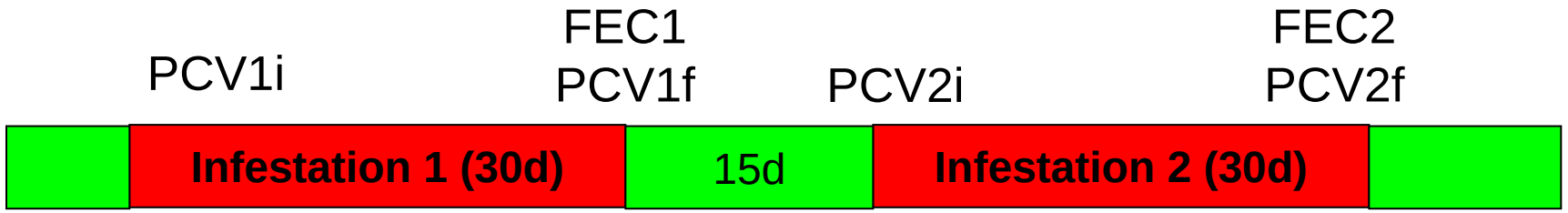
Phenotypic variability of rams

Infection 2014 : 132 rams in breeding center of Manech blond face (CDEO | Ordiarp)



=> Important variability between rams

Genetic parameters : traits and model

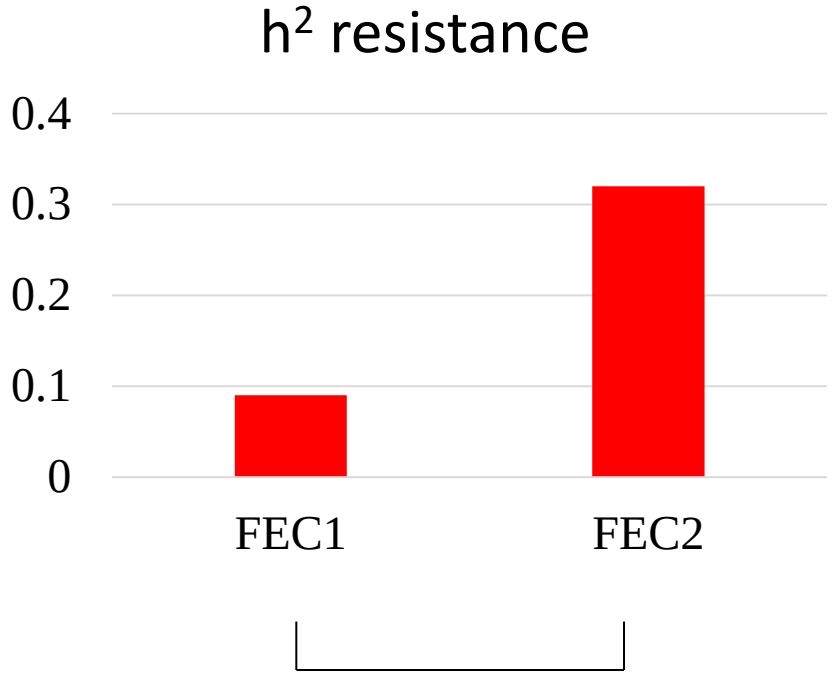


$$diffPCV1 = PCV1i - PCV1f \qquad diffPCV2 = PCV2i - PCV2f$$

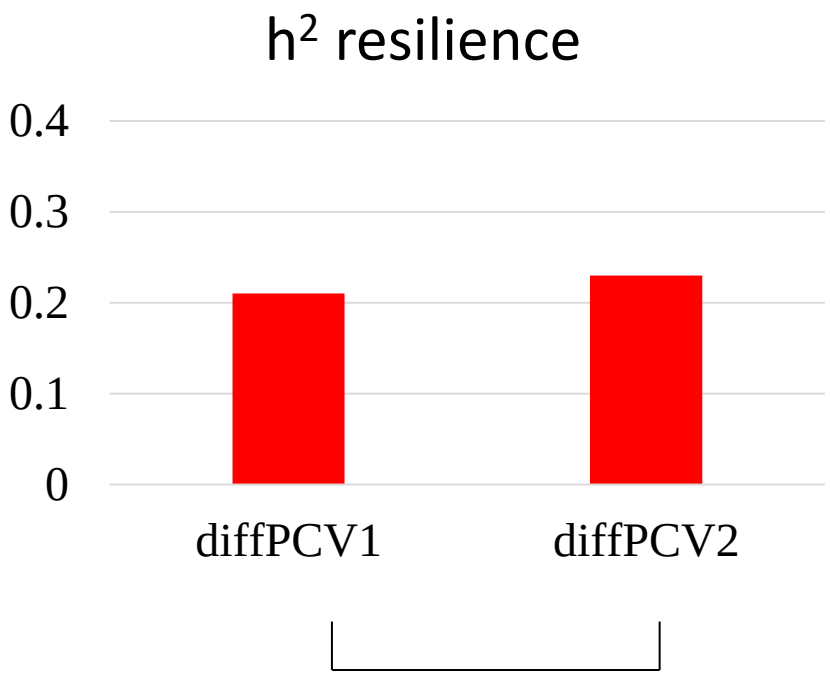
Model : $\sqrt{\text{FEC1}}$, $\sqrt{\text{FEC2}}$, diffPCV1, diffPCV2 = μ + **YEAR** + **AGE** + **RAM** + e

REML – VCE software
All rams from known sire
Average : 4.5 rams per sire

Genetic parameters resistance / resilience to nematodes at both infestations



$\rho_g = 0.92$



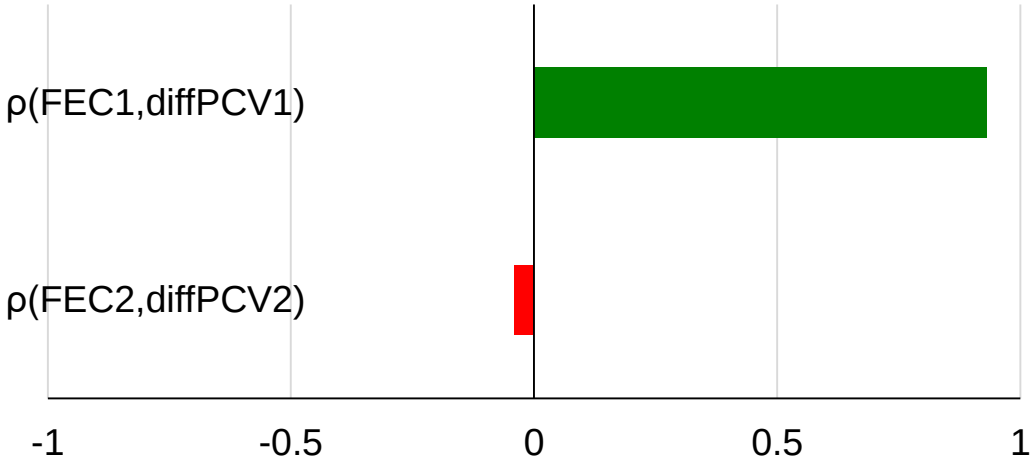
$\rho_g = -0.49$

Heritabilities moderate

h^2 FEC2> h^2 FEC1.

Surprisingly negative correlation

Genetic correlations between resistance and resilience traits at both infestations



1st infection : resistance and resilience highly correlated

2nd infection : correlation between resistance and resilience near to zero

Genetic correlation between resistance to nematodes and milk yield (MY)

- Method of estimation :

  - ✓ Genetic evaluation performed on resistance to NGI parasites traits => EBV_{FEC} & REL_{FEC}
  - ✓ $\rho_g = corr(EBV_{FEC2}, EBV_{MY}) / \sqrt{REL_{FEC2} \, x REL_{MY}}$
  - ✓ $\rho_{g\ FEC2,MY} = \mathbf{0,184}$ **(unfavorable)**

- Slight unfavorable correlation between resistance at 2nd infestation and milk yield

Conclusion, perspectives

- **Genetic variability** of resistance to nematodes exhibited in an experimental and controlled challenge
  => **selection possible**

- **Unfavorable correlation** between **resistance & milk yield**
  => to be considered in the selection objective

- **Phenotyping** resistance to nematodes **laborious and expensive**. 2 ways to reduce costs | work

  -FEC measure : quantitative real-time **PCR** from worm DNA | currently investigated

  -Decrease number of individual FEC : measure of **FEC2 only** (moderate h2, high correlation with FEC1)

Conclusion, perspectives

- **2 strategies of selection** :
  - Short-term : resistant rams (AI) in flocks with resistance to anthelmintic
  - Long-term : classical selection with selection pressure on rams in breeding center

- Genetic evaluation have been performed for 2 years. **EBVs provided** to Blond-Faced Manech breed society

ICAR issues

- Resistance to nematodes in sheep = novel trait

- **Guidelines** could be proposed for recording resistance to nematodes
  - -under natural conditions
  - -under experimental conditions

THANK YOU FOR YOUR ATTENTION

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