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Evolution in performances of French dairy cattle herds transitioning towards 3-breed crossbreeding

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Analysis of the explanatory factors of performance trends in French dairy herds transitioning towards rotational crossbreeding



***Farmers' crossbreeding practices matter as much as
changes in general farming management and initial situation of performances***

J. Quénon¹, S. Ingrand², and M.-A. Magne³

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³ Université de Toulouse, ENSFEA, INRAE, UMR AGIR, F-31320 Castanet-Tolosan, France

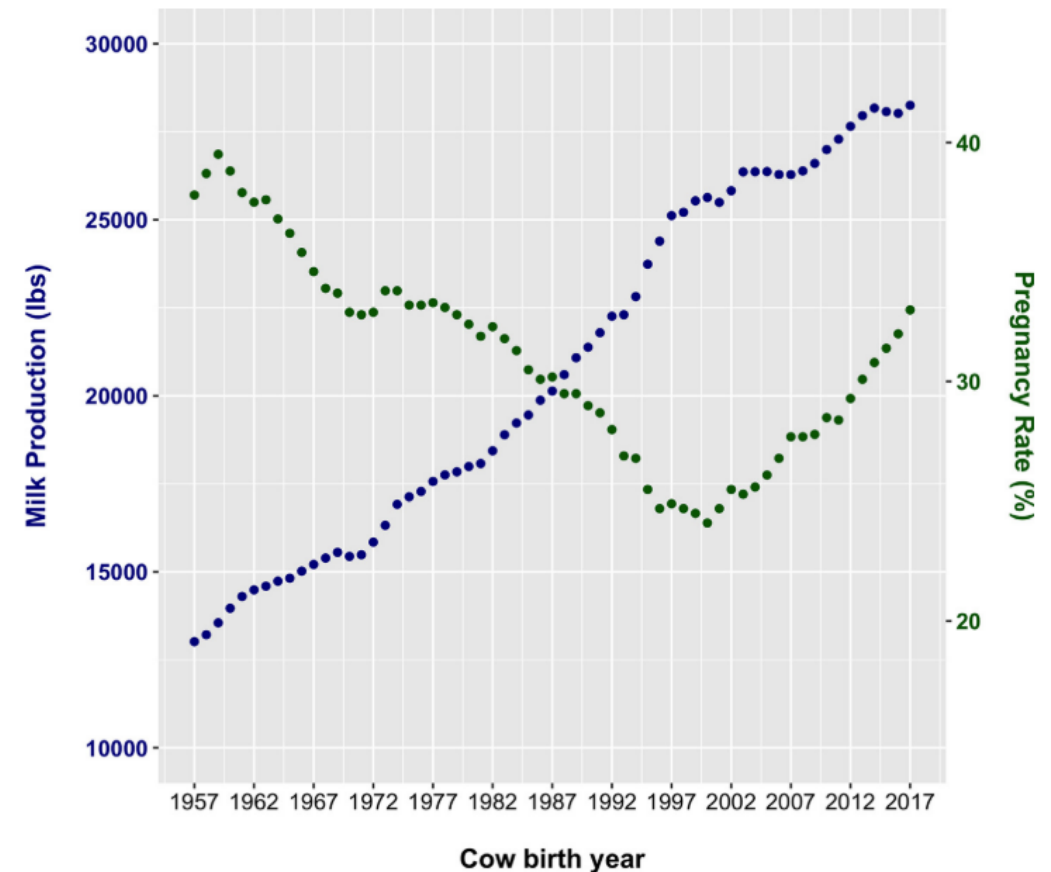
Introduction

- **Decrease in functional performances** (i.e. fertility, health, longevity) in purebred Holstein dairy cattle herds

(Kerlake et al. 2018; Brito et al., 2021; Hu et al., 2021)

- **Functional performances are main determinants of the profitability of dairy cattle systems**

(Buckley et al., 2014; De Vries, 2017; Dezetter et al., 2017)

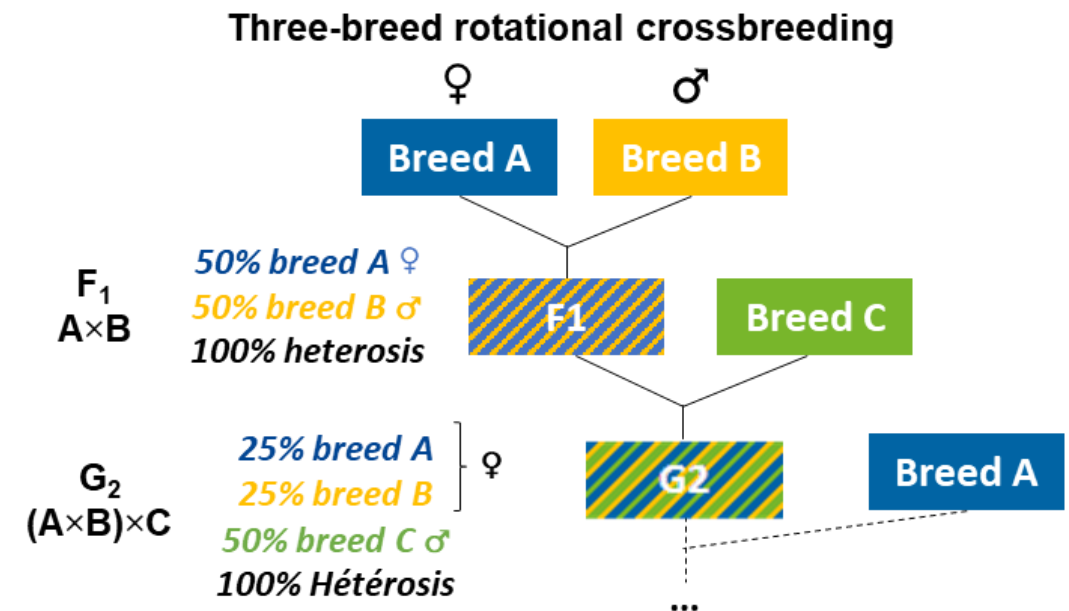


Brilo et al. (2021)

Introduction

Rotational crossbreeding?

- Crossbreeding to benefit from heterosis effect (*Penasa, 2010*) and complementarity of dairy cattle breeds (*Magne et al., 2016*)
- Three-breed rotational crossbreeding (3BC) : compromise to ensure high heterosis (83% in 3rd generation) while keeping management of crossbreeding programme simple
- Uncommon in Western countries (*Dezetter et al., 2015; Clasen et al., 2017; Magne and Quénon, 2021*)



Introduction

- Few studies assessing performances of rotational crossbreeding:
 - At the herd level
 - In the long run (post-F₁ generations)
- Mostly based on modelling (*Dezetter et al., 2017; Clasen et al., 2020*)

Modelling hypotheses



Actual technical pathways to introduce
and manage rotational crossbreeding
(*Quénon et al., 2020*)

Introduction

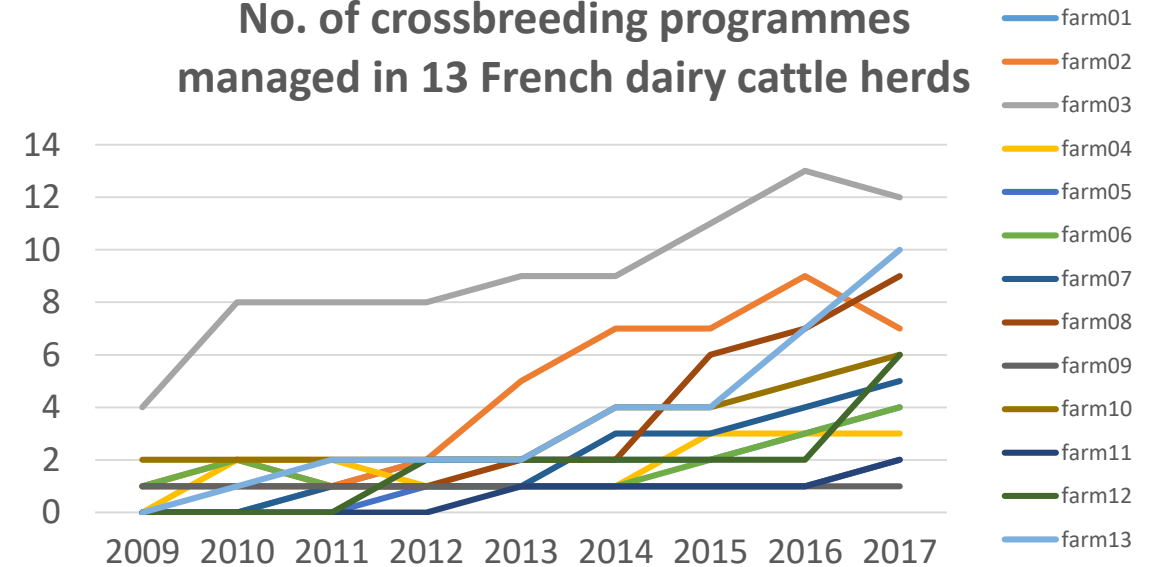
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 - At the herd level
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- Mostly based on modelling (*Dezetter et al., 2017; Clasen et al., 2020*)

Modelling hypotheses

- One crossbreeding programme



No. of crossbreeding programmes
managed in 13 French dairy cattle herds



Introduction

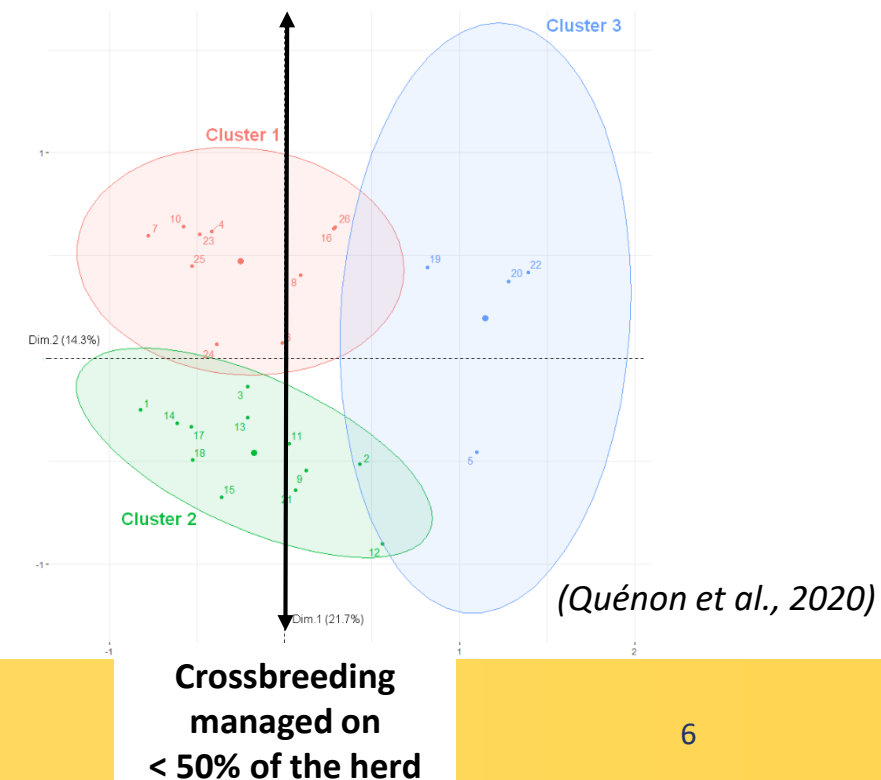
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Modelling hypotheses

- *One crossbreeding programme*
- Introduced and managed on the entire dairy herd
- At a regular and/or linear pace



Stable crossbred mating ≥ 90%
Crossbred mating peaked ≥ 90% then decrease ≥ 50%



Introduction

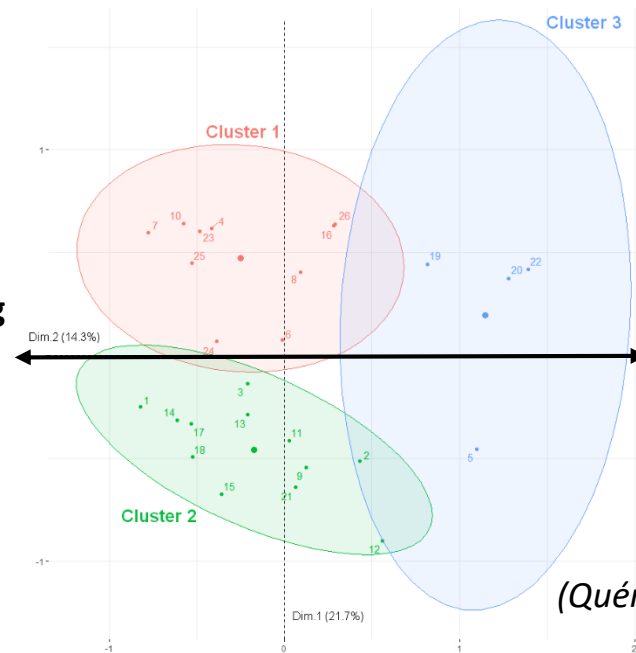
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- Mostly based on modelling (*Dezetter et al., 2017; Clasen et al., 2020*)

Modelling hypotheses

- *One crossbreeding programme*
- *Introduced and managed on the entire dairy herd*
- *At a regular and/or linear pace*
- *Without considering other farm-level changes*



Crossbreeding
fit farm-scale
changes



Crossbreeding
introduced
without other
changes

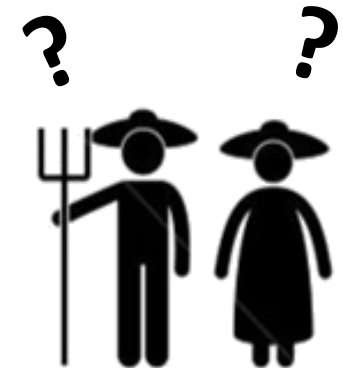
(*Quénon et al., 2020*)

Introduction

- Few studies assessing performances of rotational crossbreeding:
 - At the herd level
 - In the long run (post-F₁ generations)
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*What are the empirical **trends in the performances of herds** in which rotational crossbreeding is introduced?*



Introduction

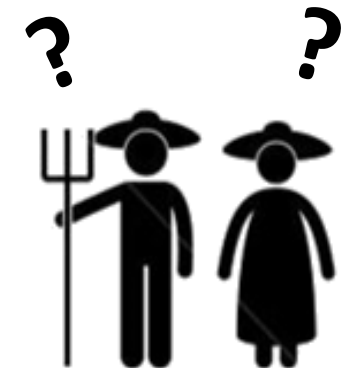
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What are the empirical trends in the performances of herds in which rotational crossbreeding is introduced?



What are the main factors that explain such trends?



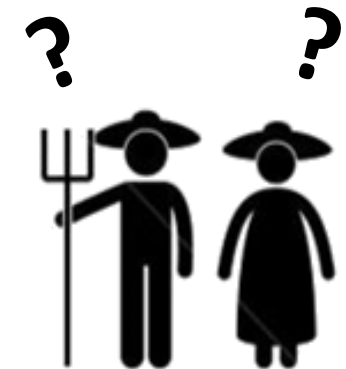
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➔ *What are the empirical **trends in the performances of herds** in which rotational crossbreeding is introduced?*

➔ *What are **the main factors that explain** such trends?*

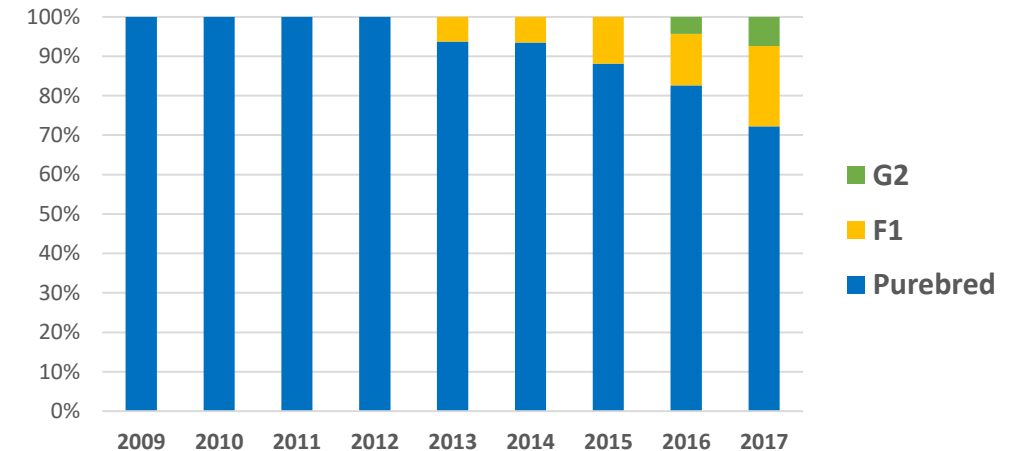
➔ *To what extent **do crossbreeding practices explain** such trends?*



Material and methods

- 13 French dairy farms
- Study period: 2009-2017
- Introduction of crossbreeding varied among sampled farms
 - Some introduced it **during the study period 2009-2017**

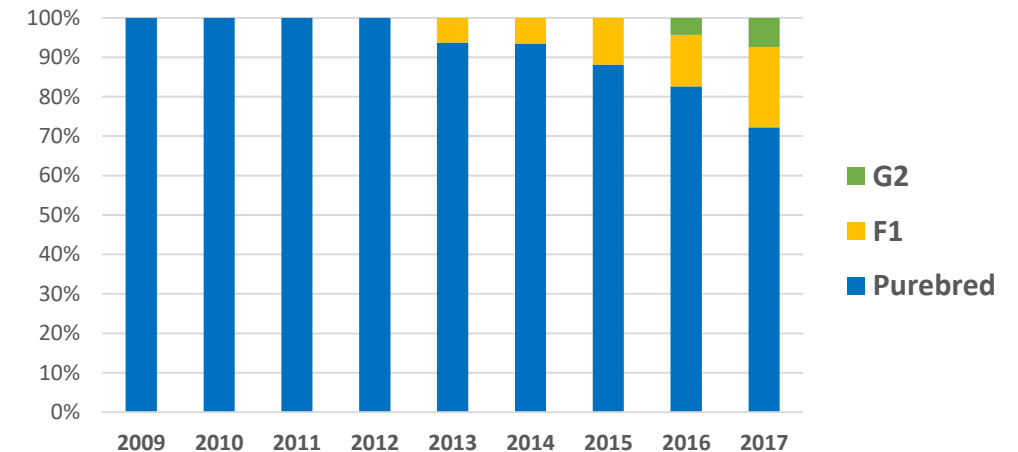
Herd #1 introduced crossbreeding during the period 2009-2017



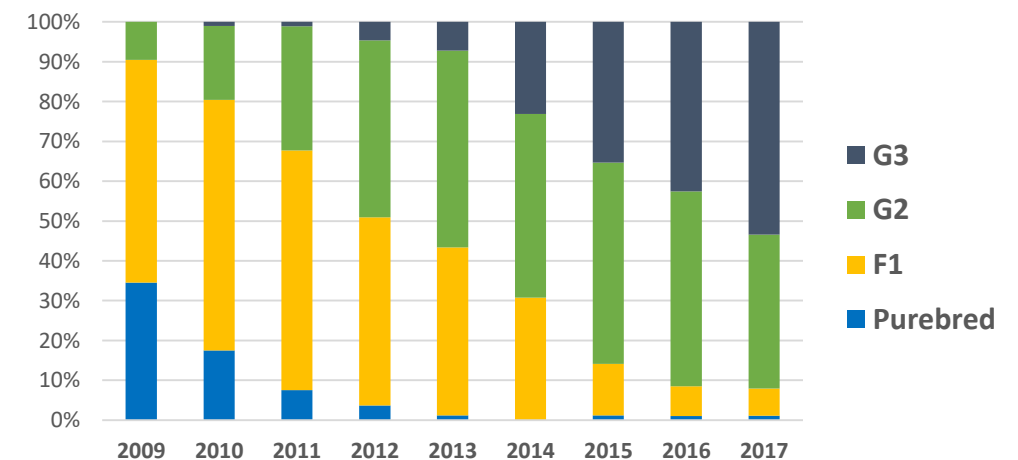
Material and methods

- 13 French dairy farms
- Study period: 2009-2017
- Introduction of crossbreeding varied among sampled farms
 - Some introduced it **during the study period 2009-2017**
 - Some introduced crossbreeding **before 2009**

Herd #1 introduced crossbreeding during the period 2009-2017



Herd #2 introduced crossbreeding before 2009



Material and methods

1. DATA COLLECTION & EDITING

Milk Record Organisation

5 Herds' performances
2009-2017

- **Milk productivity** (kg/cow)
- **Milk solids content** (g/kg/cow)
- **Fertility** (% of high fertile cows in the herd: Days Open < 117 days)
- **Somatic cell score** (% of low-SCS cows)
- **Longevity** (% of cows in 4th lactation)

Material and methods

1. DATA COLLECTION & EDITING

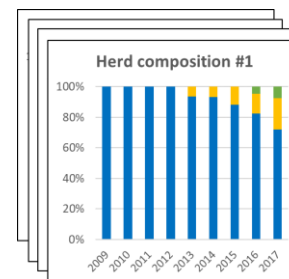
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French National System
of Genetic Information

Herds' compositions in purebred, F₁, G₂, etc.
2009-2017



Crossbreeding practices

Material and methods

1. DATA COLLECTION & EDITING

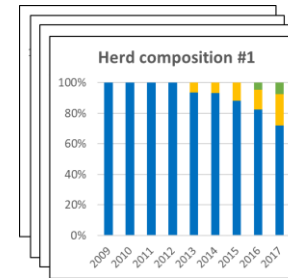
Milk Record Organisation

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Crossbreeding practices

Semi-directive interviews

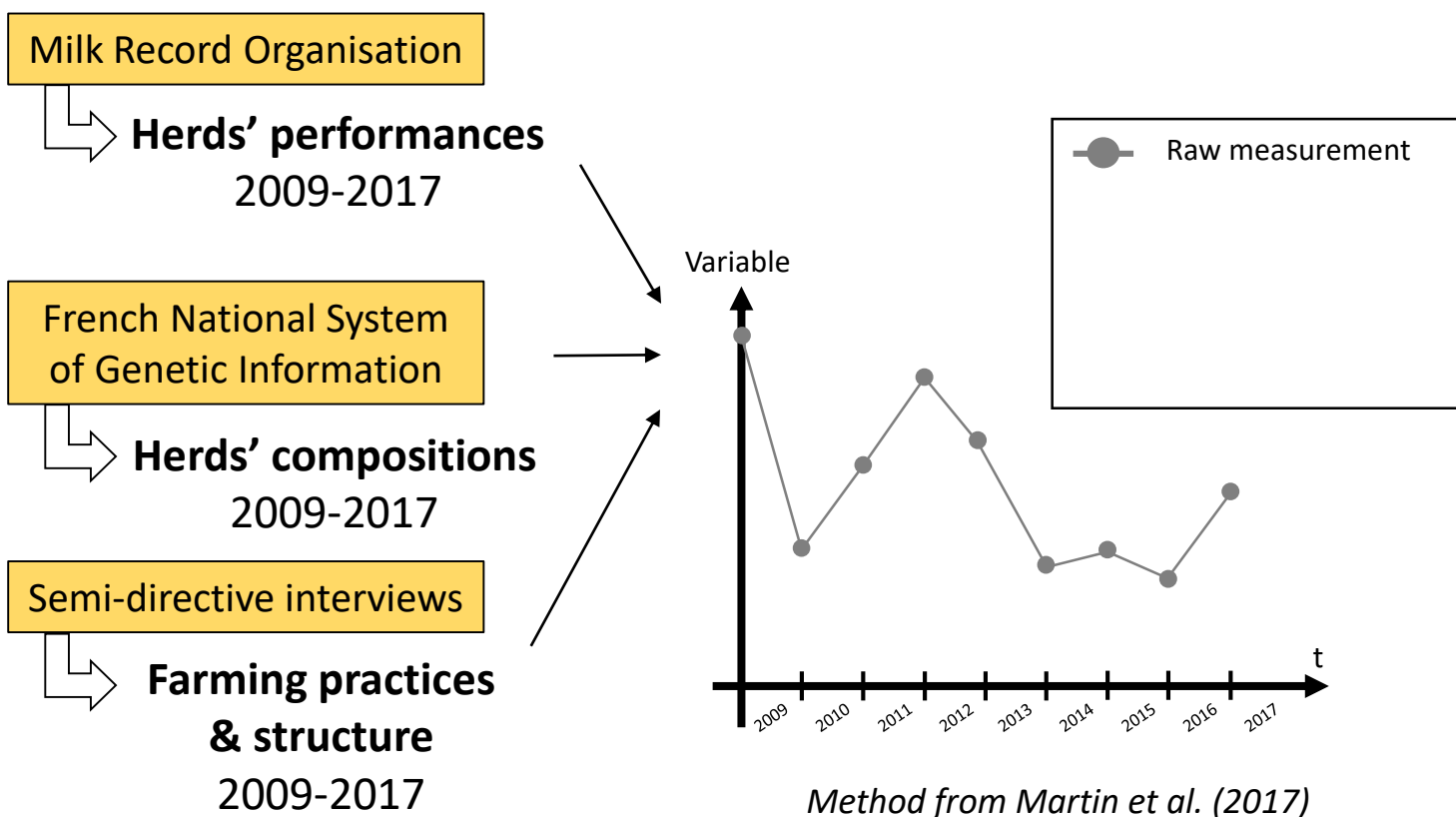
Farming practices
& structure
2009-2017

- Herd size, total agricultural area, etc.
- Crop rotation: % of grassland in main fodder area, etc.
- Conversion to organic farming vs. stable conventional/organic farming system
- Technical pathway to manage crossbreeding (Quénon et al., 2020)

Material and methods

1. DATA COLLECTION & EDITING

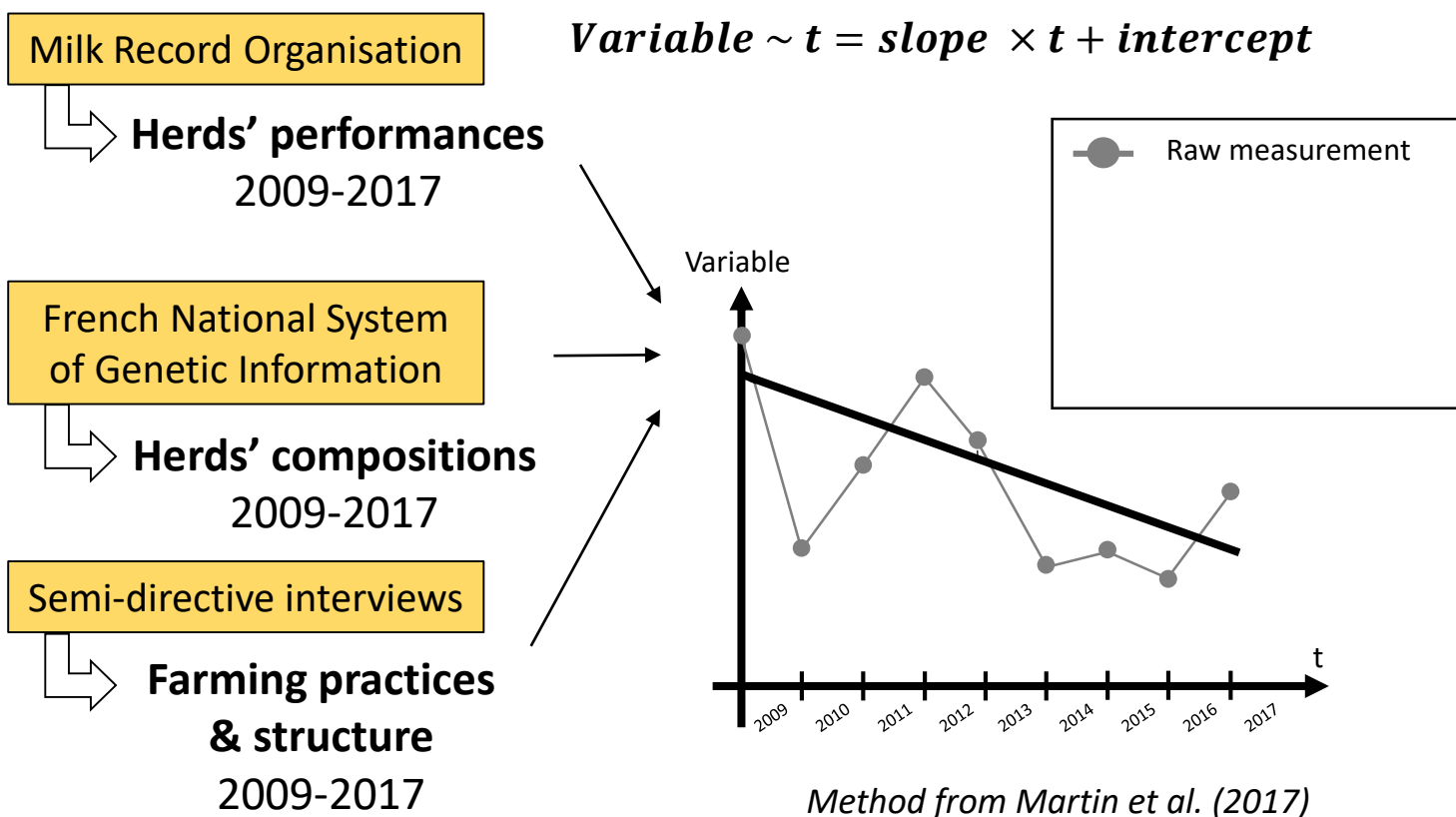
2. LINEAR REGRESSIONS



Material and methods

1. DATA COLLECTION & EDITING

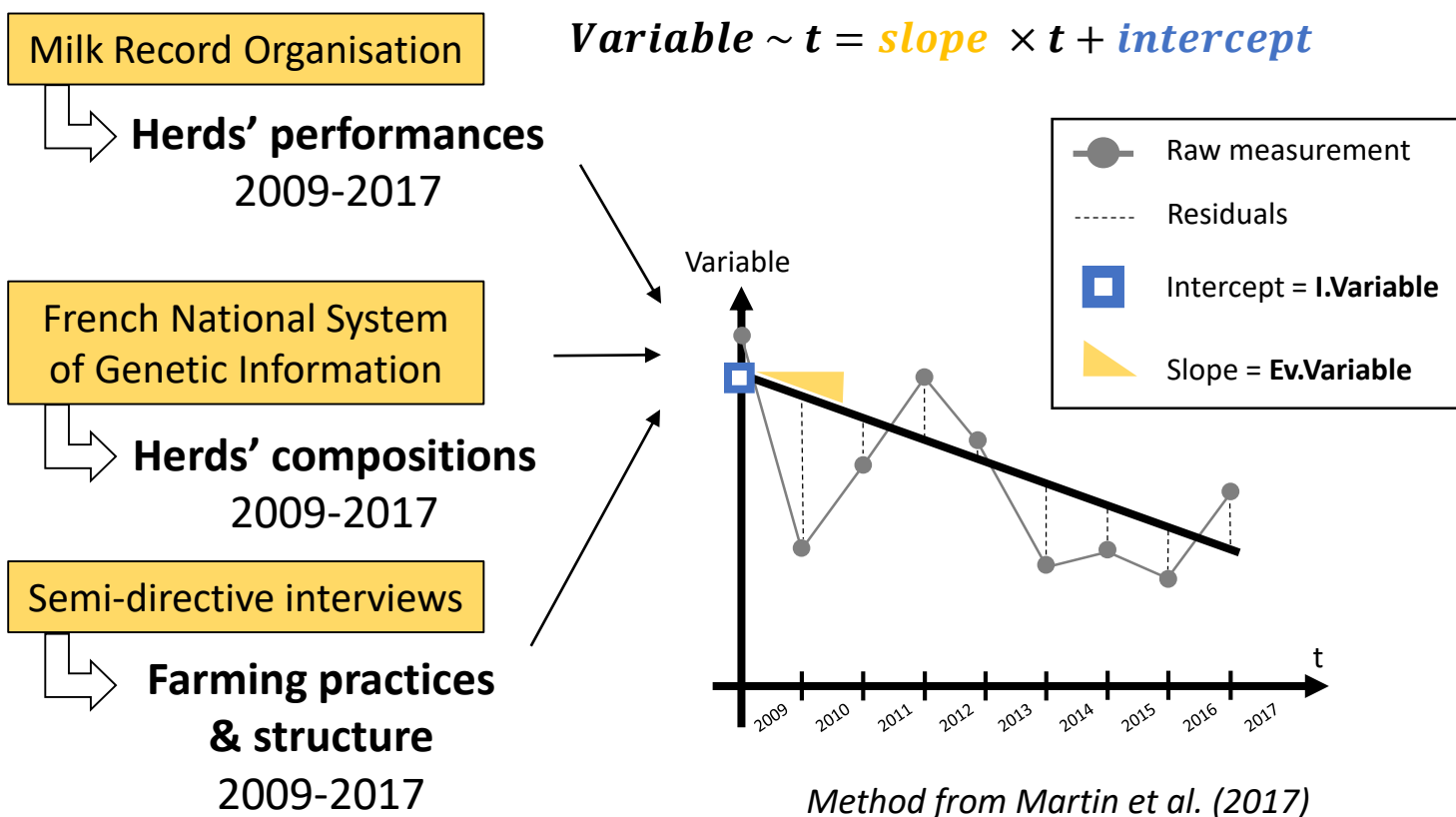
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Material and methods

1. DATA COLLECTION & EDITING

2. LINEAR REGRESSIONS



Material and methods

1. DATA COLLECTION & EDITING

2. LINEAR REGRESSIONS

Milk Record Organisation

Herds' performances
2009-2017

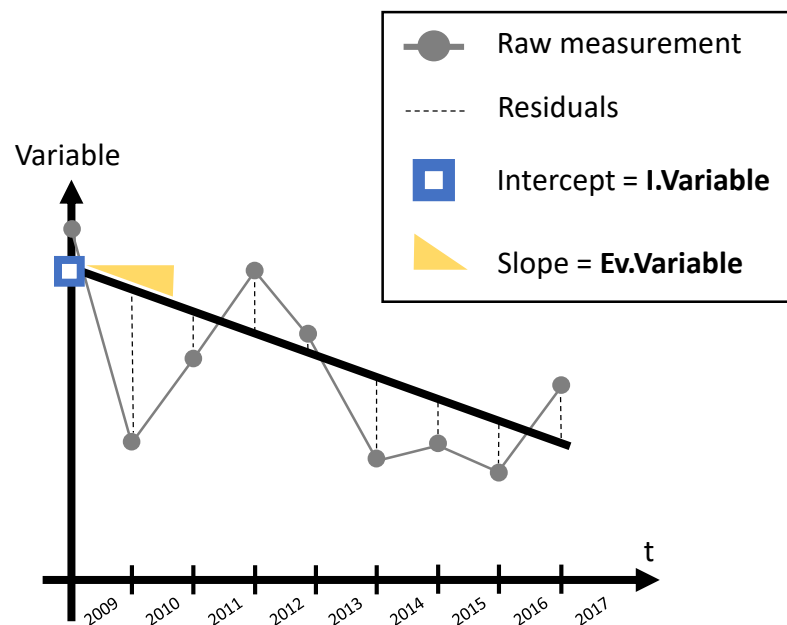
French National System
of Genetic Information

Herds' compositions
2009-2017

Semi-directive interviews

Farming practices
& structure
2009-2017

$$\text{Variable} \sim t = \text{slope} \times t + \text{intercept}$$



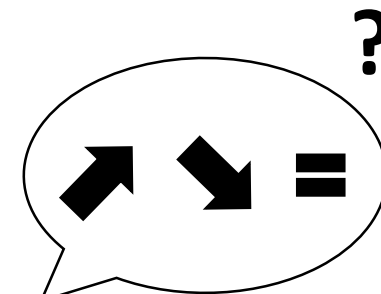
Method from Martin et al. (2017)

Ev.Performance

I.Performance

I.Practice

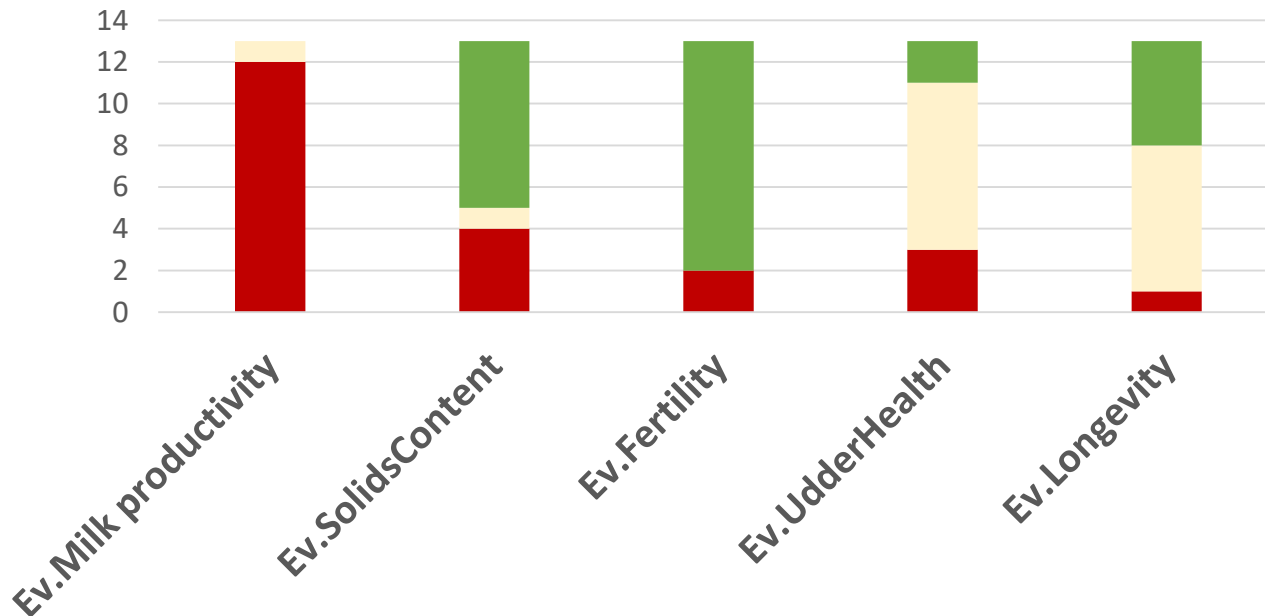
Ev.Practice



Results

2009-2017 trends in herds performances (n=13)

No. of herds



Values of slope



■ Unequivocal trends:

- **Decrease** in milk productivity (12/13)
- **Increase** in fertility (11/13)
- **Increase** in solids contents (8/13)



consistent with:

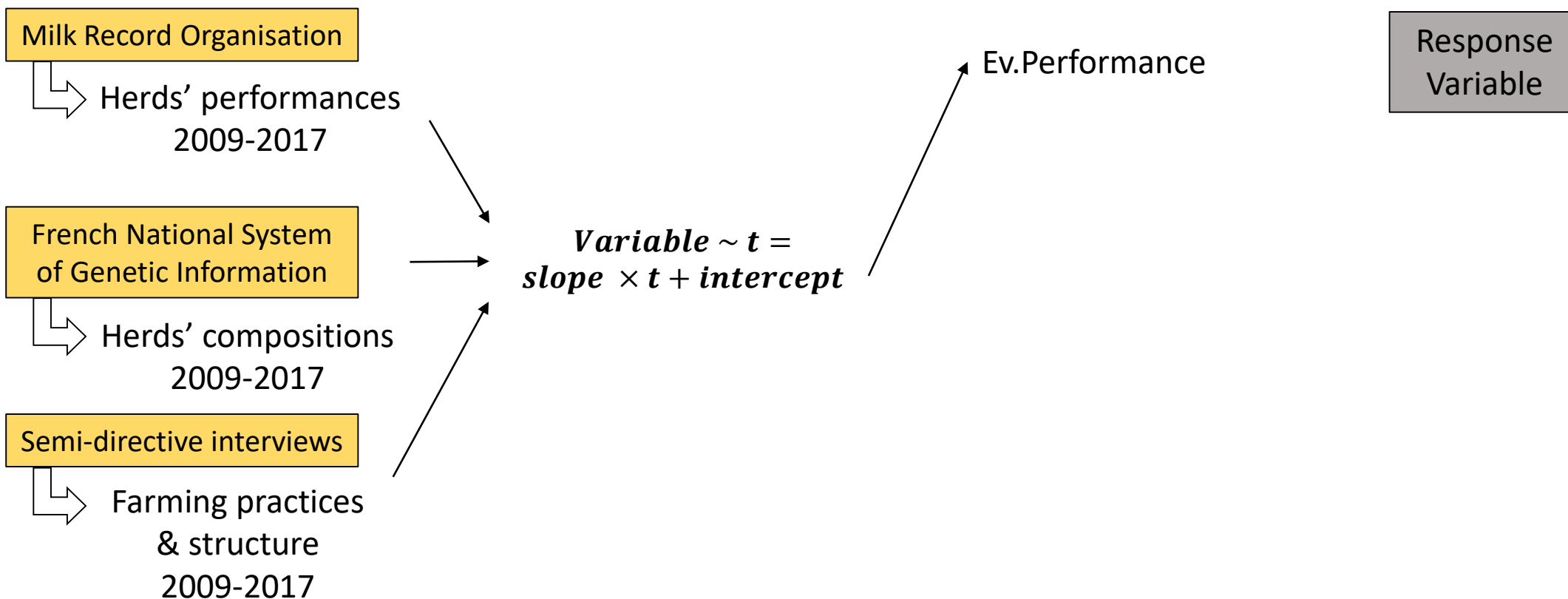
- Crossbreeding performances at animal level (*Dezetter et al., 2015, 2017; Clasen et al., 2020*)
 - Farmers' drivers to introduce dairy crossbreeding (*Buckley et al., 2014; Magne and Quénon, 2021*)
- ### ■ More unclear trends for udder health and longevity

Material and methods

1. DATA COLLECTION & EDITING

2. LINEAR REGRESSIONS

3. PARTIAL LEAST SQUARES REGRESSION

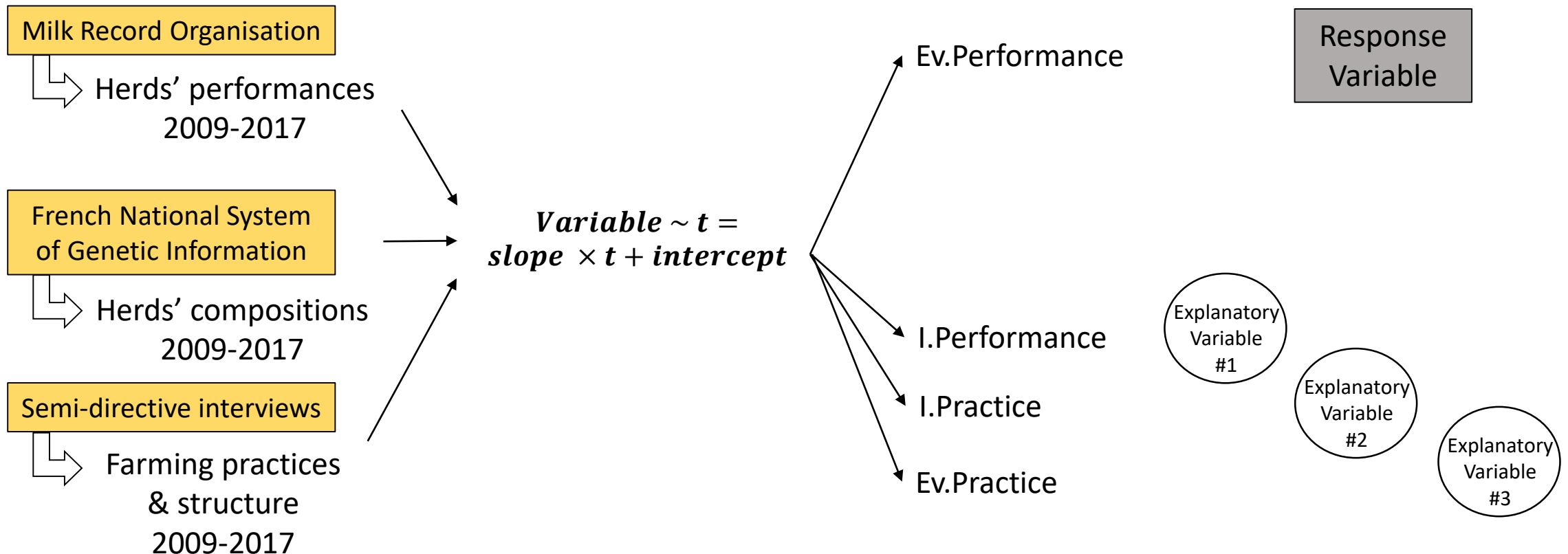


Material and methods

1. DATA COLLECTION & EDITING

2. LINEAR REGRESSIONS

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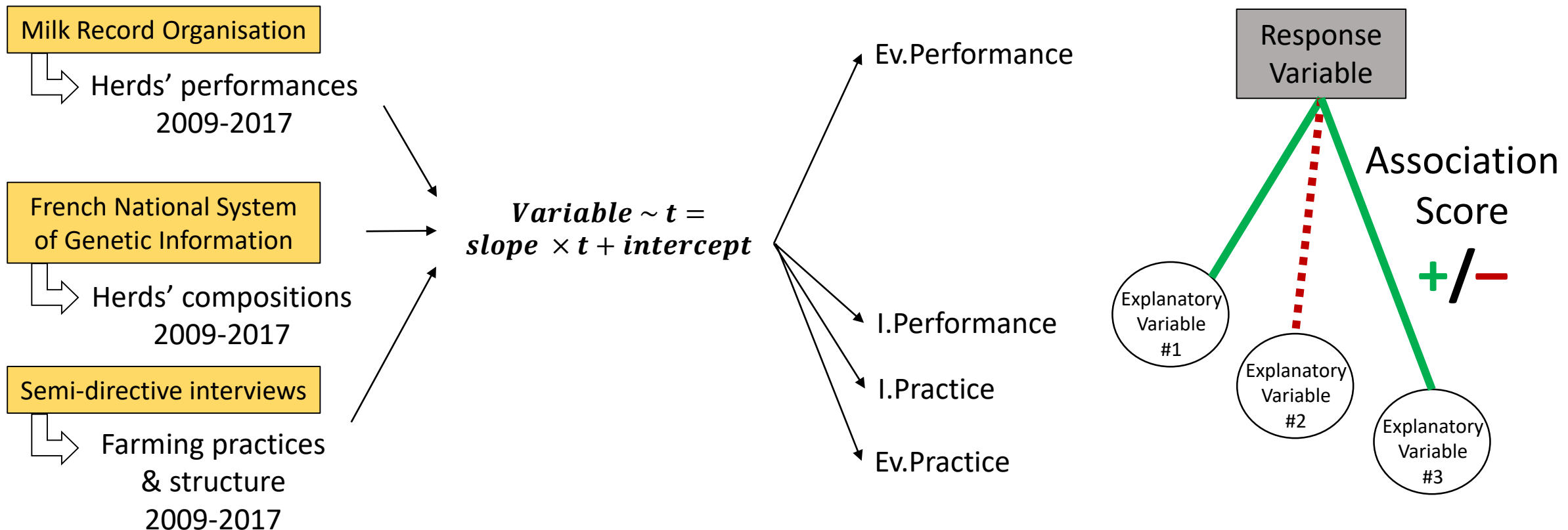


Material and methods

1. DATA COLLECTION & EDITING

2. LINEAR REGRESSIONS

3. PARTIAL LEAST SQUARES REGRESSION



Results

Component 1

Explanatory variables	Herd performance (response variable)		
	Ev. Milk productivity	Ev. Udder health	Ev. Longevity
I. F1	+0.58	+0.45	-0.53
Ev. G3_3b	+0.52	/	-0.47
TPG3	+0.44	/	/
Converting to OF	-0.50	/	+0.45
Ev. F1	-0.58	-0.44	+0.52
I. PB	-0.59	-0.45	+0.54

Results

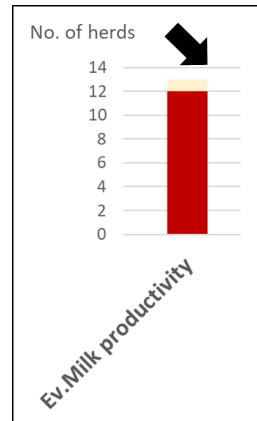
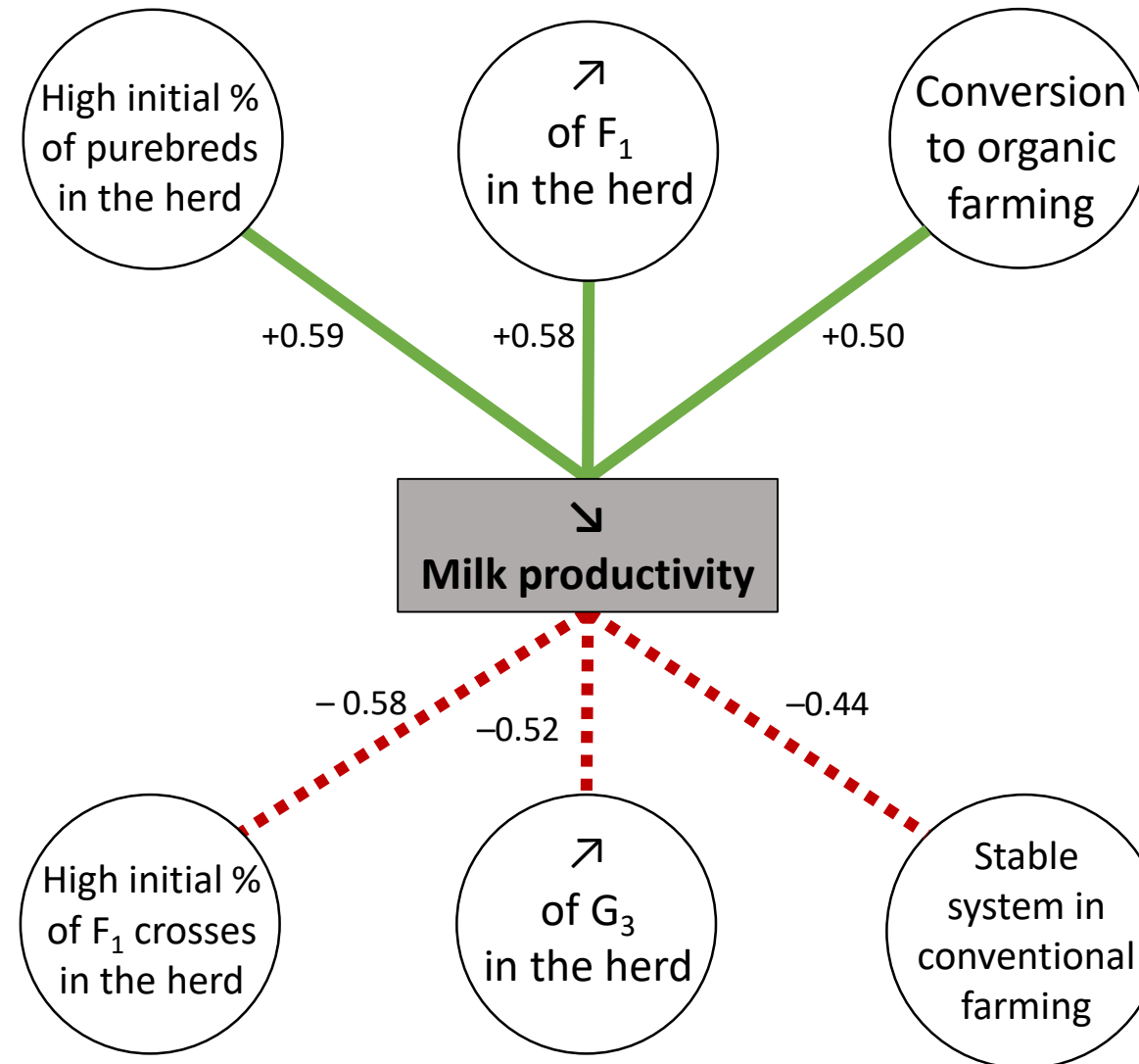
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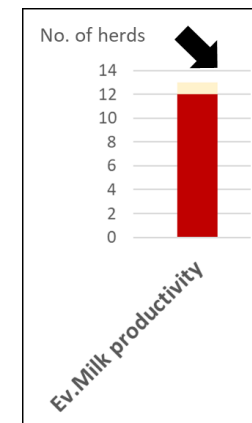
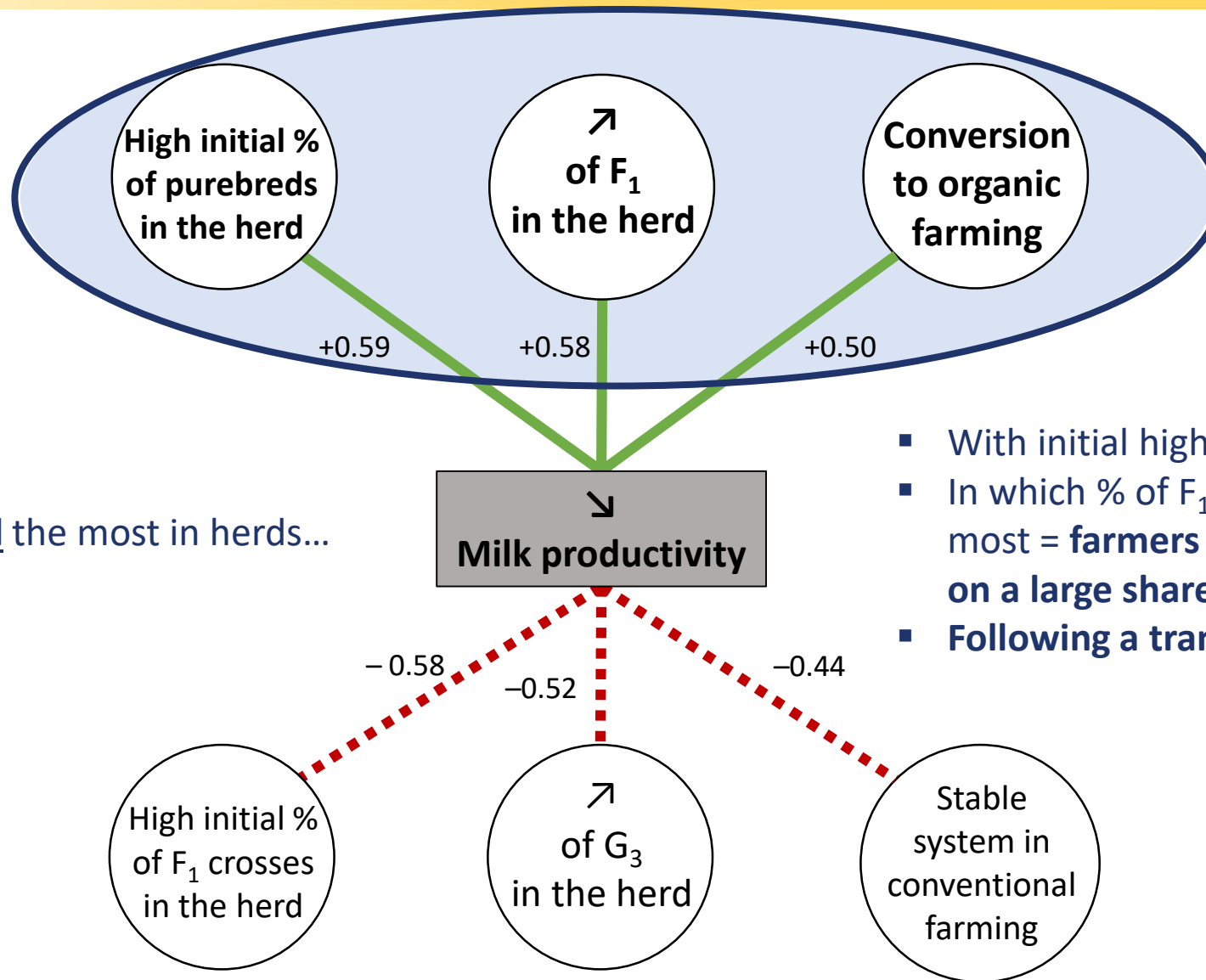
No. of herds

Ev. Milk productivity

Results



Results

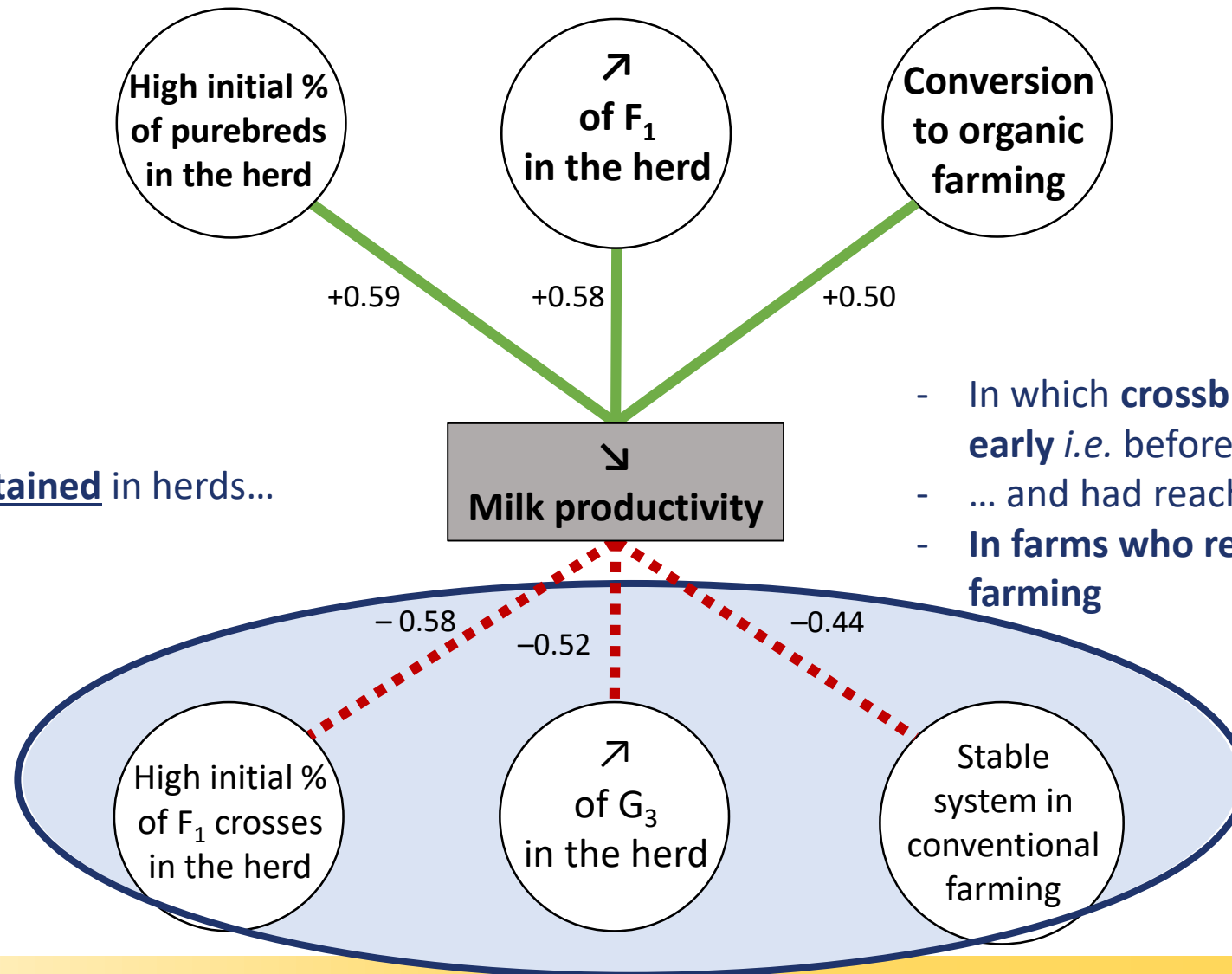


Milk productivity decreased the most in herds...

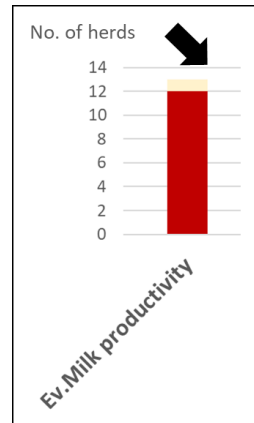
- With initial high % of purebred cows
- In which % of F₁ crosses increased the most = **farmers introduced crossbreeding on a large share of the herd**
- **Following a transition to organic farming**

Results

Milk productivity was maintained in herds...



- In which **crossbreeding was introduced early** *i.e.* before the study period...
- ... and had reached the G₃ backcross-stage
- **In farms who remained in conventional farming**



Results

Component 1

Explanatory variables	Herd performance (response variable)		
	Ev. Milk productivity	Ev. Udder health	Ev. Longevity
I. F1	+0.58	+0.45	-0.53
Ev. G3_3b	+0.52	/	-0.47
TPG3	+0.44	/	/
Converting to OF	-0.50	/	+0.45
Ev. F1	-0.58	-0.44	+0.52
I. PB	-0.59	-0.45	+0.54

Component 2

Explanatory Variables	Herd performance (response variable)	
	Ev. Milk solids content	Ev. Fertility
Ev. All crosses	+0.45	-0.31
I. Fertility	+0.45	-0.30
TPG1	+0.35	-0.24
Ev. G2_3b	+0.28	/
I. Milk solids content	-0.32	/
I. Milk productivity	-0.40	+0,27

Results

Component 1

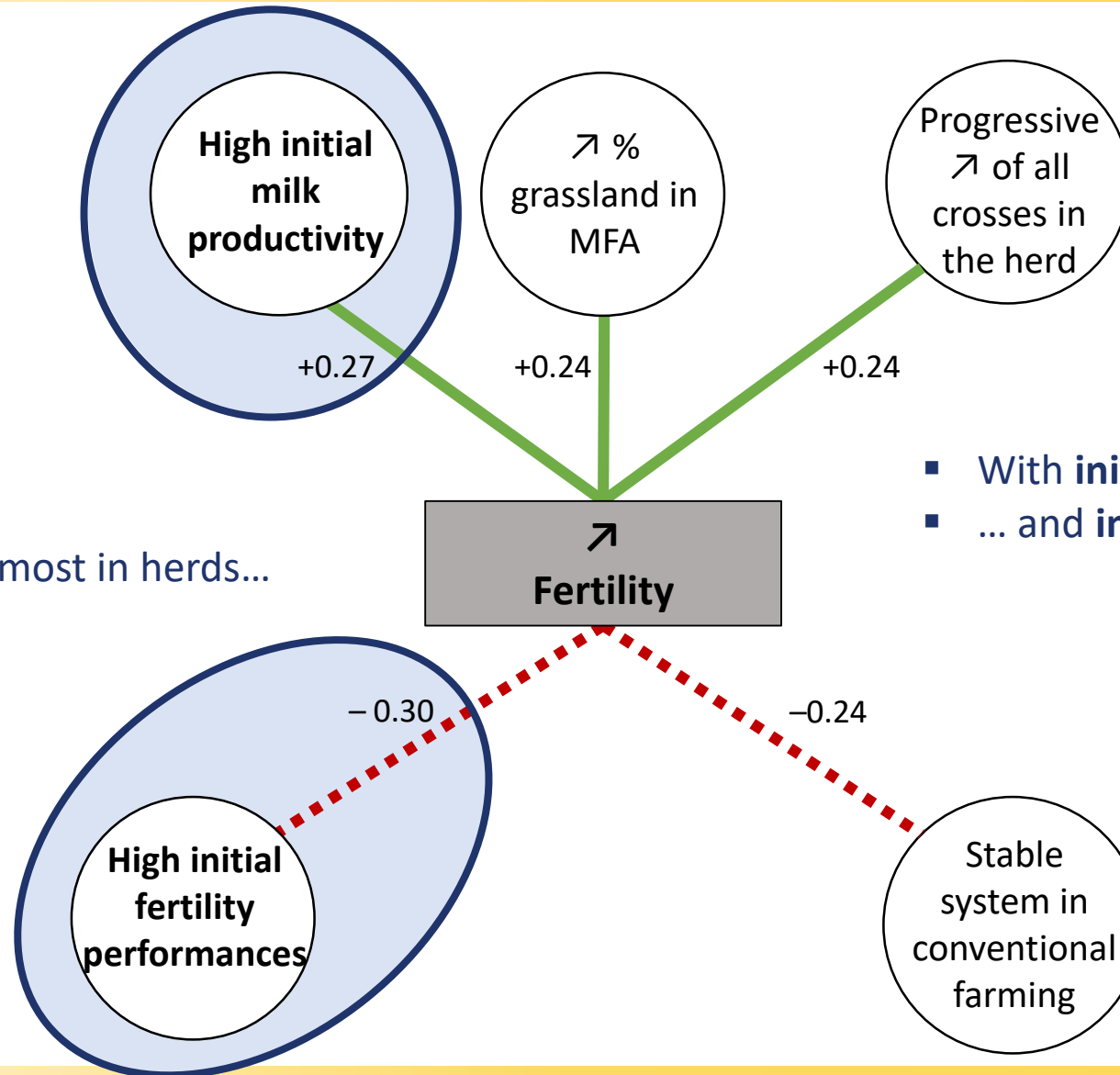
Explanatory variables	Herd performance (response variable)	
	Ev. Milk productivity	Ev. Fertility
I. F1	+0.58	+0.33
Ev. G3_3b	+0.52	+0.17
TPG3	+0.44	+0.15
Converting to OF	-0.50	+0.12
Ev. F1	-0.58	+0.02
I. PB	-0.59	+0.14

No. of herds	
Ev. Milk productivity	13
Ev. Fertility	1

Component 2

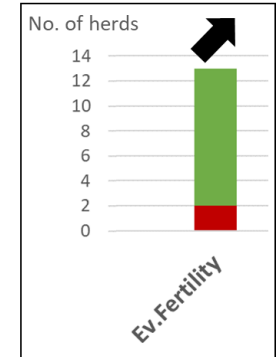
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I. Milk solids content	-0.32	/
I. Milk productivity	-0.40	+0,27

Results



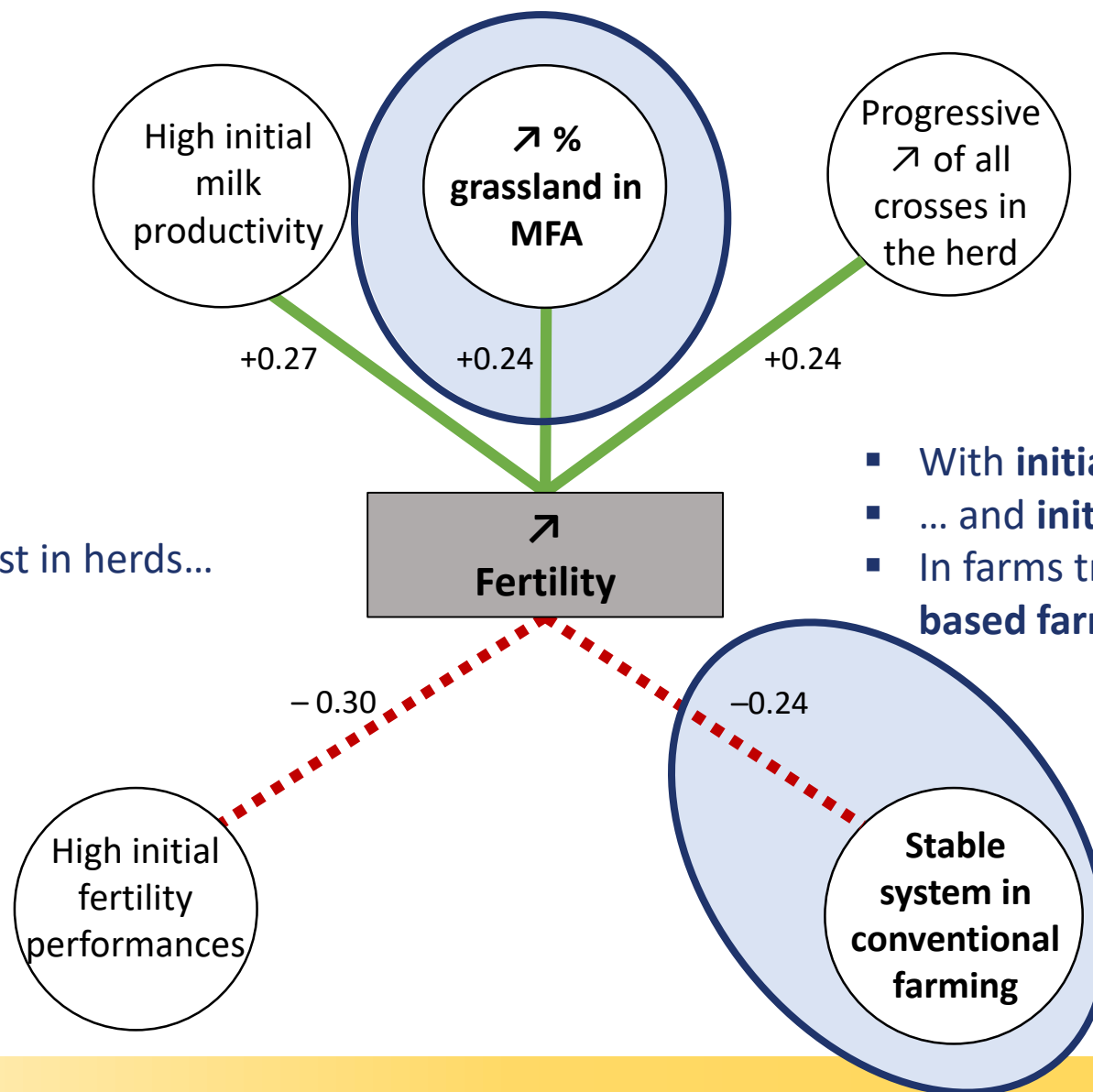
Fertility increased the most in herds...

- With **initial high milk** performances...
- ... and **initial low fertility** performances

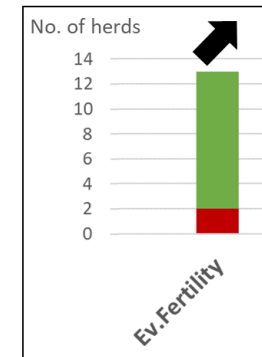


Results

Fertility increased the most in herds...

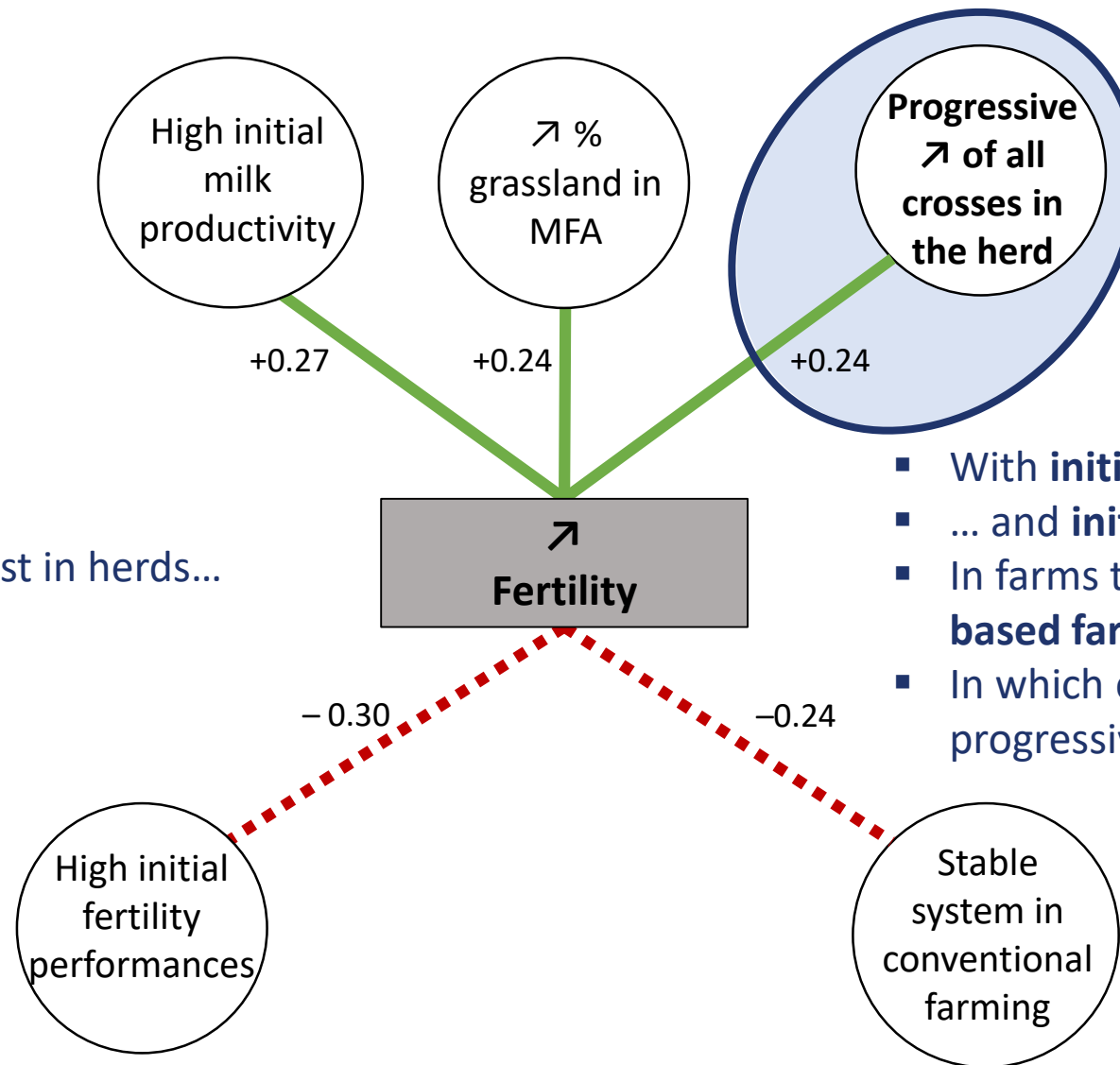


- With **initial high milk** performances...
- ... and **initial low fertility** performances
- In farms transitioning **towards grassland-based farming systems**...

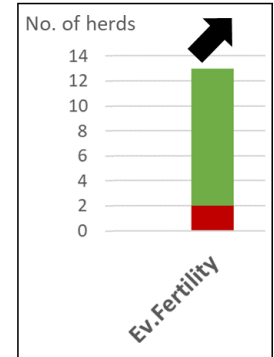


Results

Fertility increased the most in herds...



- With **initial high milk** performances...
- ... and **initial low fertility** performances
- In farms transitioning **towards grassland-based farming systems**...
- In which crossbreeding was introduced progressively



Conclusion

- Crossbreeding practices are a major factor on trends in herds performance but as much as :
 - Farm-scale changes (e.g. conversion to organic farming)
 - The initial performance situation: “margin for improvement” (e.g. fertility)
- ➡ Crossbreeding is one explanatory factor among others: specific management of dairy crossbreeding required to be consistent with general farm management practices

Conclusion

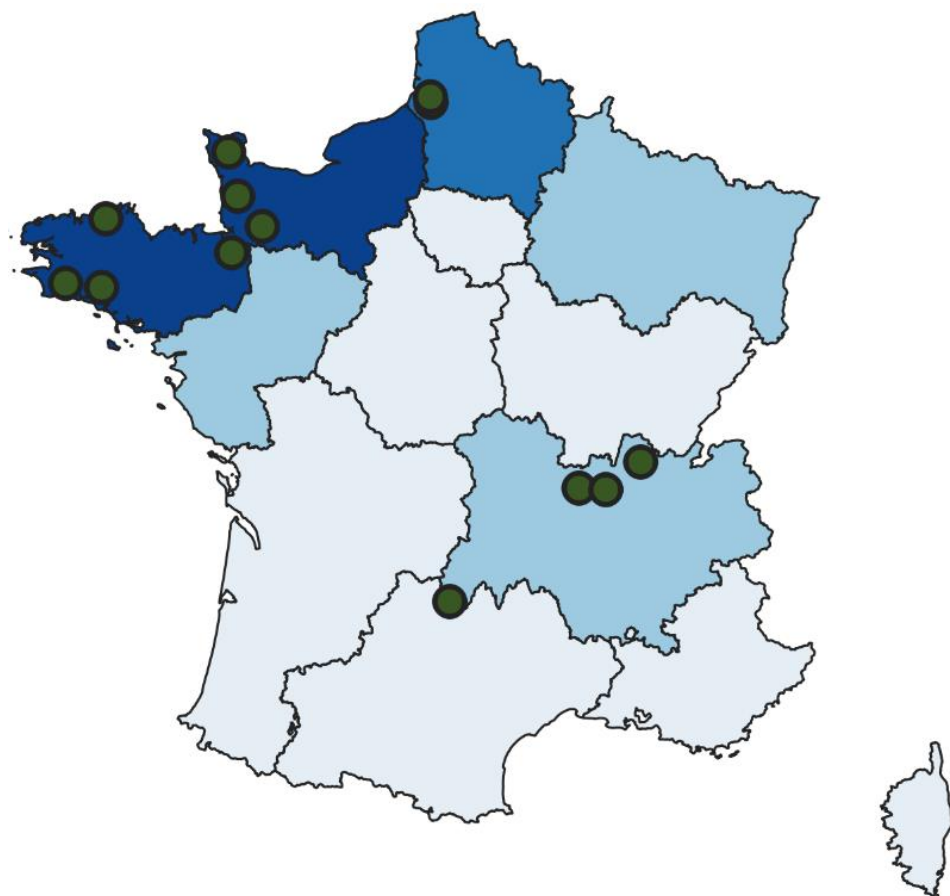
- The different generation of crosses (F_1 , G_2 , G_3 , *etc.*) have different performances: their relative % in the herd and the evolution of herd composition while managing crossbreeding induces contrasting trends in performance on the long run
 - ➔ Need to assess empirical trends in herd performances on longer period of time and on larger sample

Thank you for your attention
Any questions ?



Credits: Julien Quénon

Material and methods



No. of crossbred females

