TOWARDS IMPROVEMENT OF RUMINANT BREEDING THROUGH GENOMIC AND EPIGENOMIC APPROACHES

Selection for antagonistic traits must balance diversity in terms of genetic correlation

Beatriz C.D. Cuyabano[1], Mariana R. Motta[2], Sophie Aguerre[1,3], and Sophie Mattalia[1,3]

[1]INRAE, GABI, Université Paris Saclay, AgroParisTech, France

[2]Department of Statistics, University of Campinas, Brazil

[3]Idele, UMT eBIS, France

75th EAAP Annual Meeting

01 September 2024

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000226

Introduction

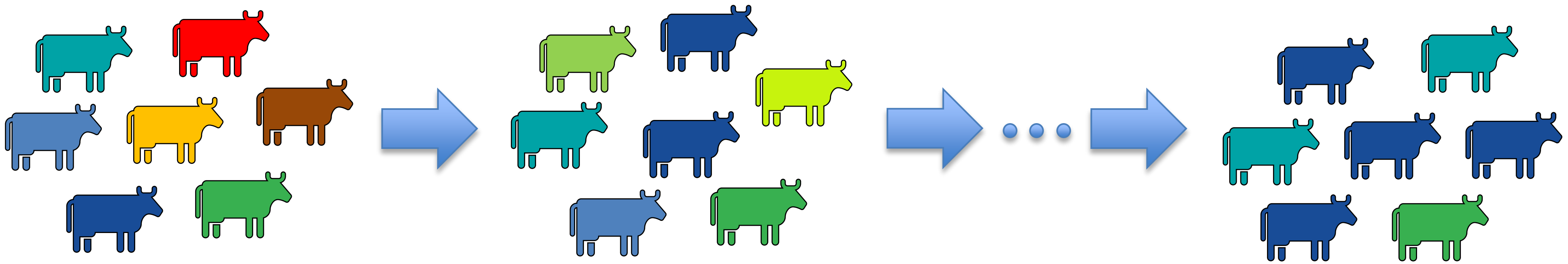
- Genetic parameters have long been considered as static in genetic evaluations,
- Principle of ignorable selection: multi-generational predicted breeding values are as accurate as possible, given (co)variance parameters estimated at a base population,
- Selection leads to loss of genetic diversity: Bulmer effect.

Introduction

- Genetic parameters have long been considered as static in genetic evaluations,
- Principle of ignorable selection: multi-generational predicted breeding values are as accurate as possible, given (co)variance parameters estimated at a base population,
- Selection leads to loss of genetic diversity: Bulmer effect.

Introduction

- Genetic parameters have long been considered as static in genetic evaluations,
- Principle of ignorable selection: multi-generational predicted breeding values are as accurate as possible, given (co)variance parameters estimated at a base population,
- Selection leads to loss of genetic diversity: Bulmer effect.



Introduction

- Loss of genetic diversity in terms of variance has been widely studied,
- Loss of genetic diversity in terms of genetic correlation is little explored,
  - Positively correlated traits: generally not a problem,
  - Antagonistic traits: requires caution!

Introduction

- Loss of genetic diversity in terms of variance has been widely studied,
- Loss of genetic diversity in terms of genetic correlation is little explored,
    - Positively correlated traits: generally not a problem,
    - Antagonistic traits: requires caution!

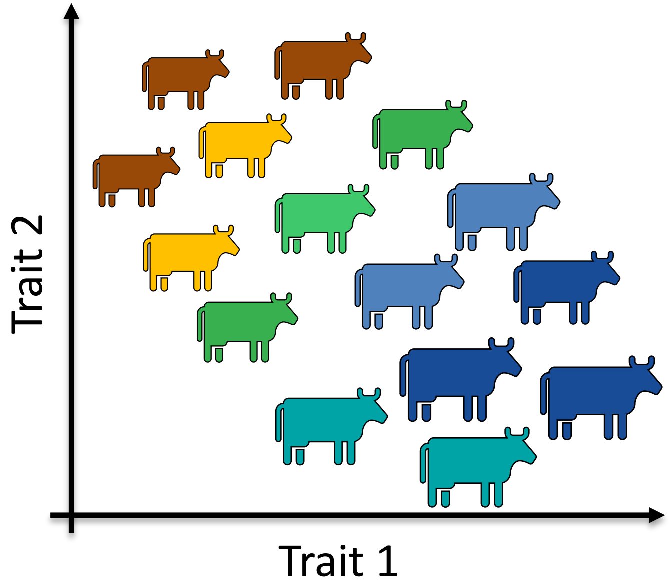
Introduction

- Loss of genetic diversity in terms of variance has been widely studied,
- Loss of genetic diversity in terms of genetic correlation is little explored,
    - Positively correlated traits: generally not a problem,
    - Antagonistic traits: requires caution!

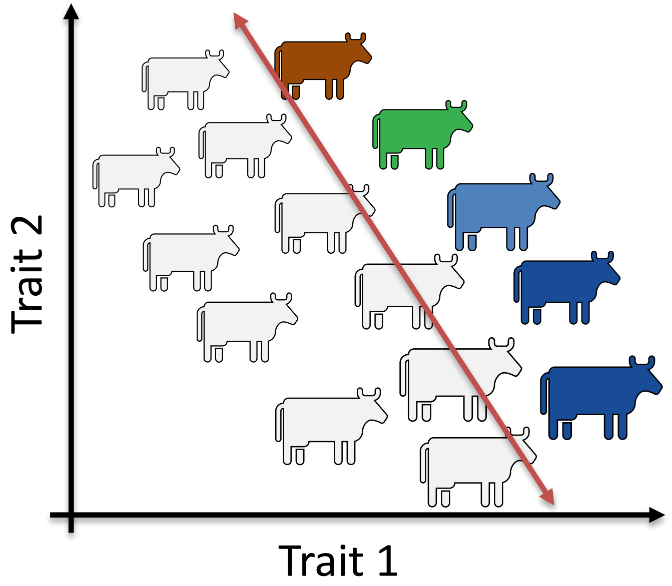
Introduction

- Loss of genetic diversity in terms of variance has been widely studied,
- Loss of genetic diversity in terms of genetic correlation is little explored,
  - Positively correlated traits: generally not a problem,
  - Antagonistic traits: requires caution!

Genetic diversity in terms of genetic correlation

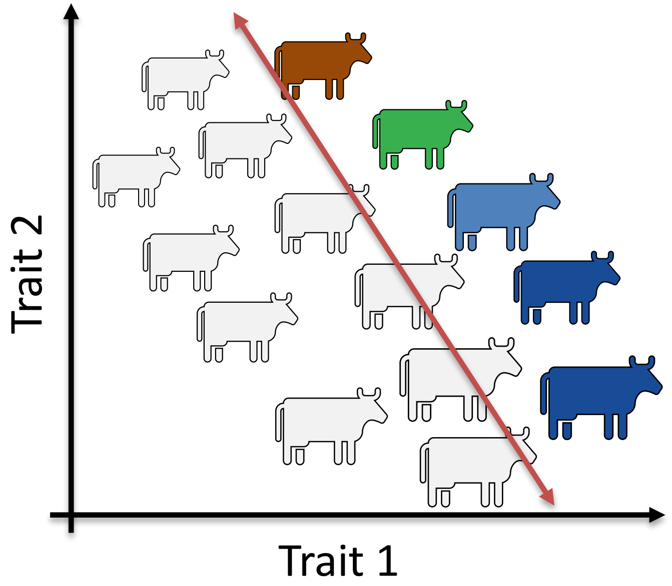


Genetic diversity in terms of genetic correlation



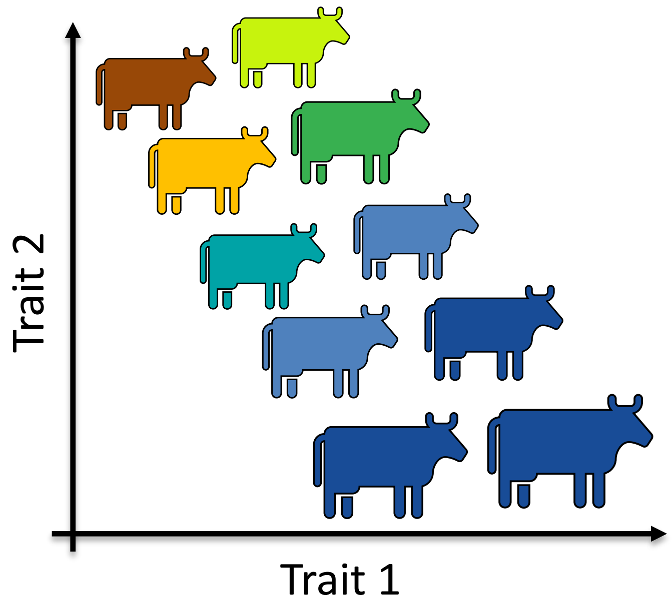
Selection is based on a linear combination of the traits

Genetic diversity in terms of genetic correlation



Selection is based on a linear combination of the traits

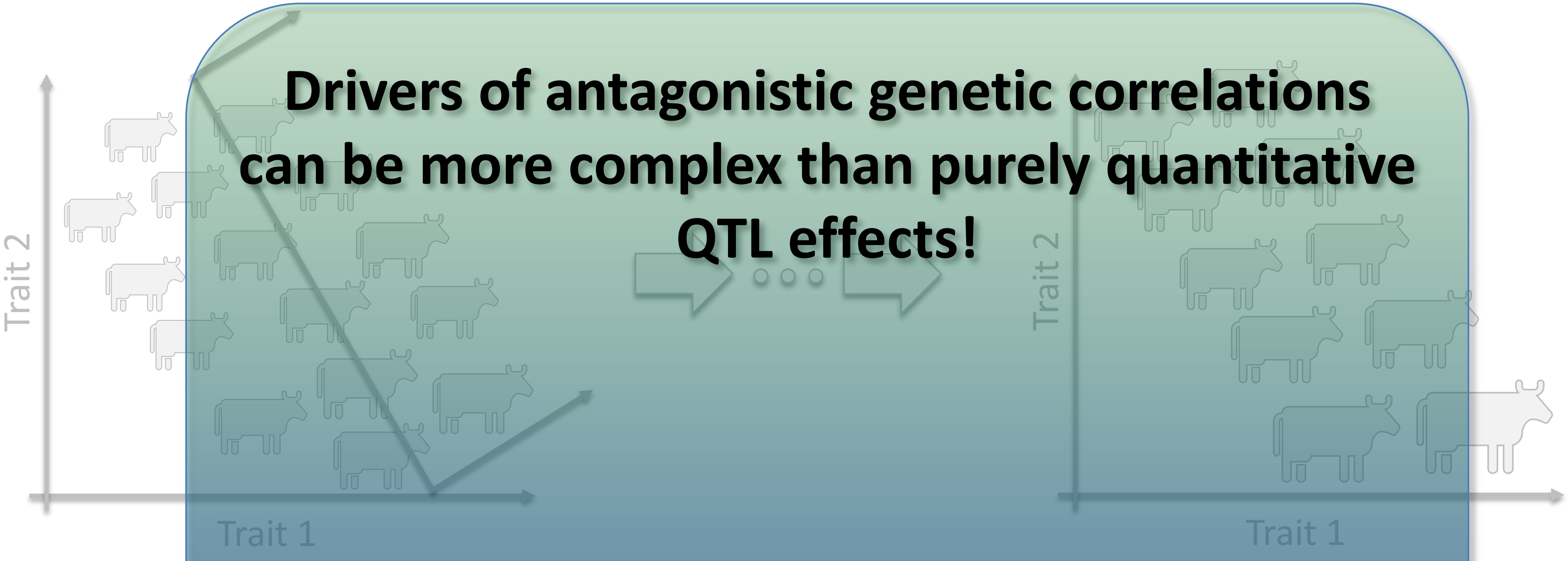
if the correlation is purely quantitative



Intensified genetic correlation between the traits

Genetic diversity in terms of genetic correlation

Drivers of antagonistic genetic correlations can be more complex than purely quantitative QTL effects!



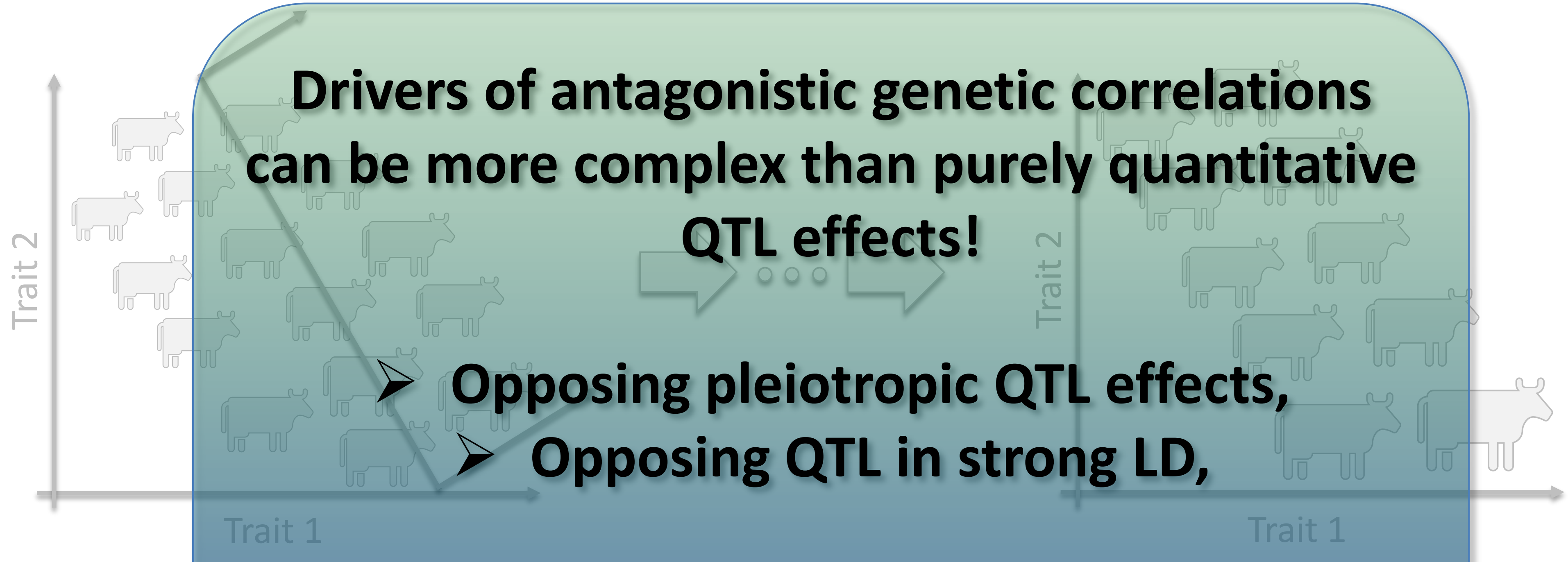
Selection is based on a linear combination of the traits

Intensified genetic correlation between the traits

Genetic diversity in terms of genetic correlation

Drivers of antagonistic genetic correlations can be more complex than purely quantitative QTL effects!

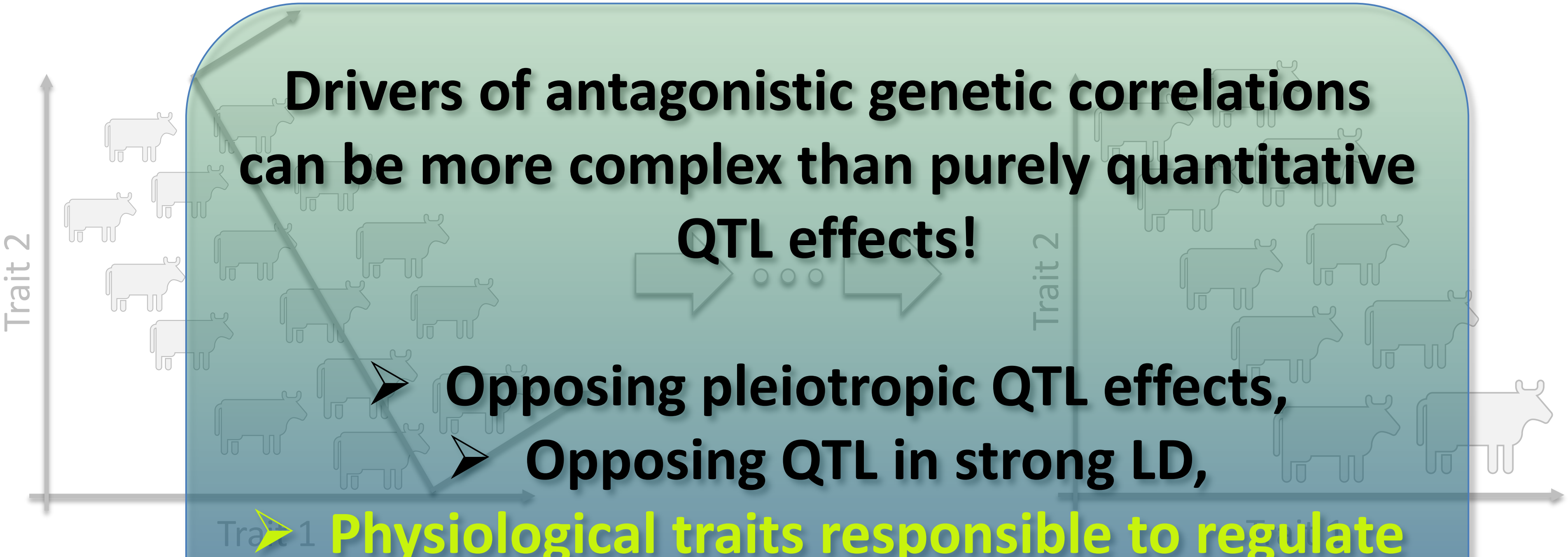
- **Opposing pleiotropic QTL effects,**
- **Opposing QTL in strong LD,**



Selection is based on a linear combination of the traits

Intensified genetic correlation between the traits

Genetic diversity in terms of genetic correlation



Drivers of antagonistic genetic correlations can be more complex than purely quantitative QTL effects!

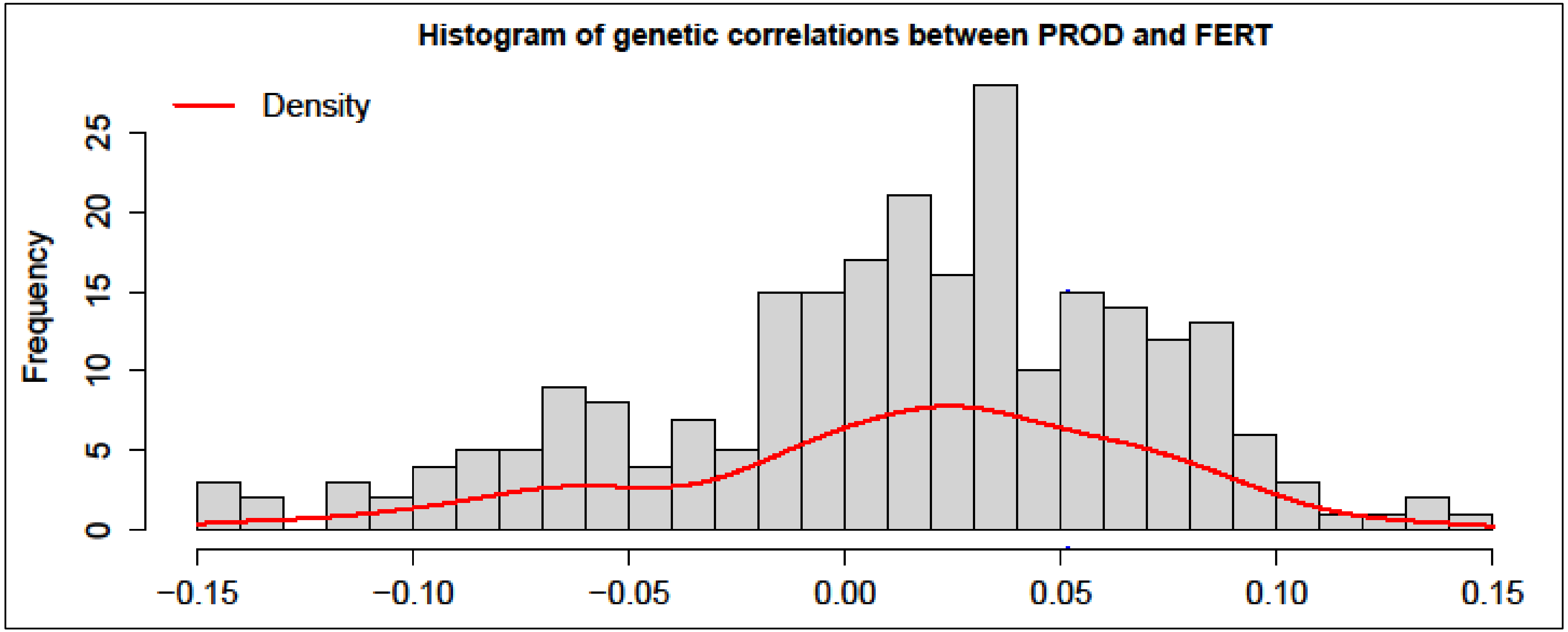
- **Opposing pleiotropic QTL effects,**
- **Opposing QTL in strong LD,**
- **Physiological traits responsible to regulate trade-offs.**

Selection is based on a linear combination of the traits

Intensified genetic correlation between the traits

Genetic correlation between antagonistic traits

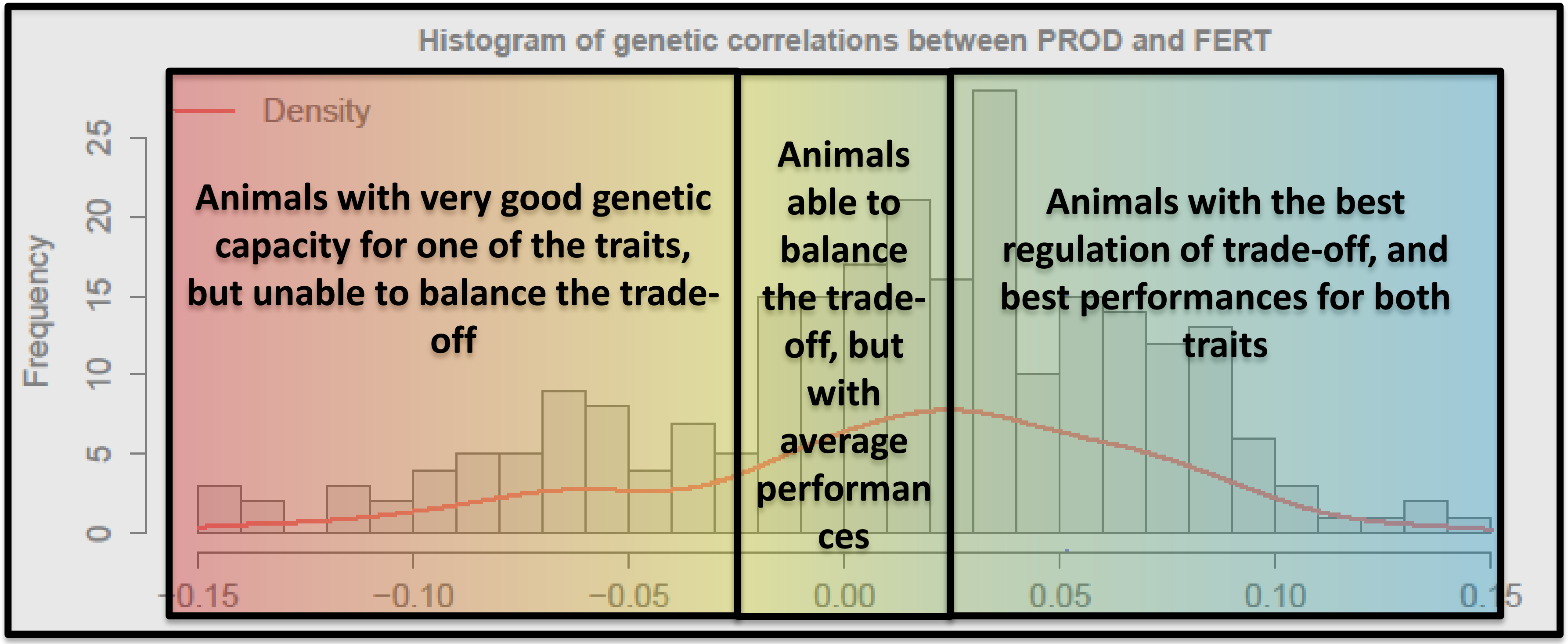
- I will focus the discussion on the trade-off between production and fertility.



(data extracted from the French Montbéliarde population; 247 sires with > 500 daughters)

Selection for diversity of genetic correlation

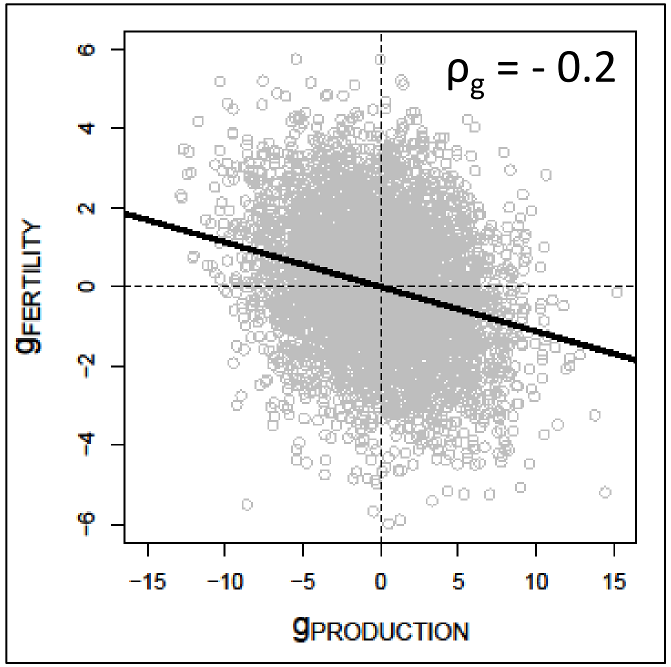
➢ I will focus the discussion on the trade-off between production and fertility.



(data extracted from the French Montbéliarde population; 247 sires with > 500 daughters)

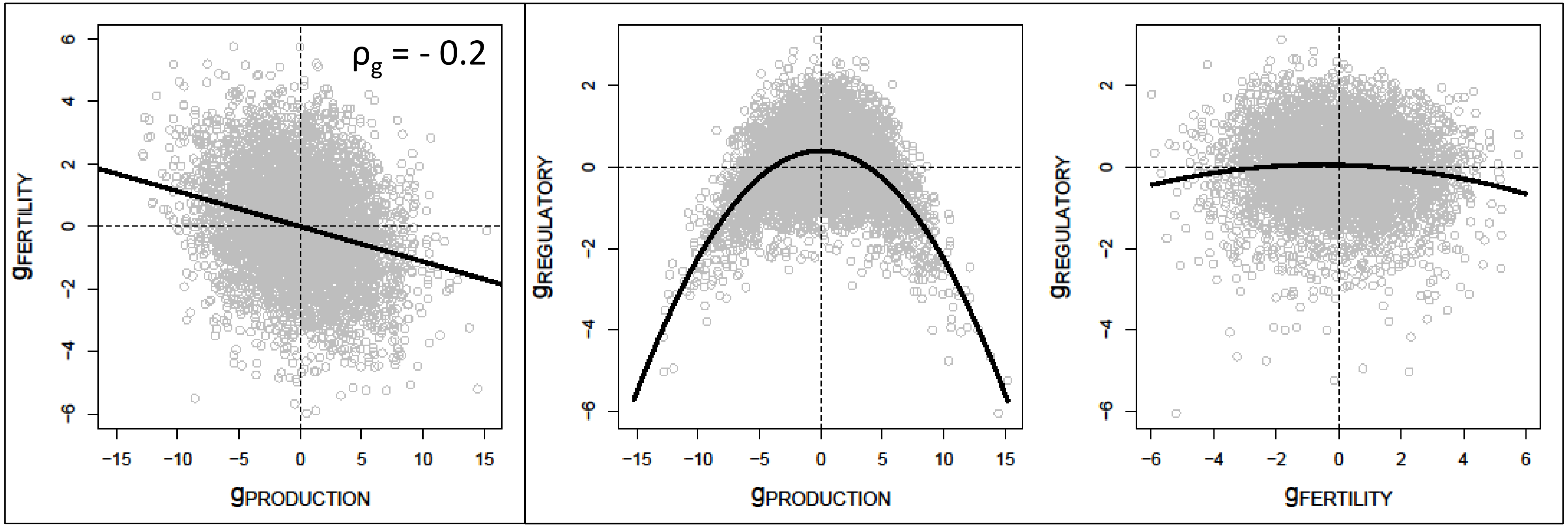
Genetic correlation between antagonistic traits

- I will focus the discussion on the trade-off between production and fertility.

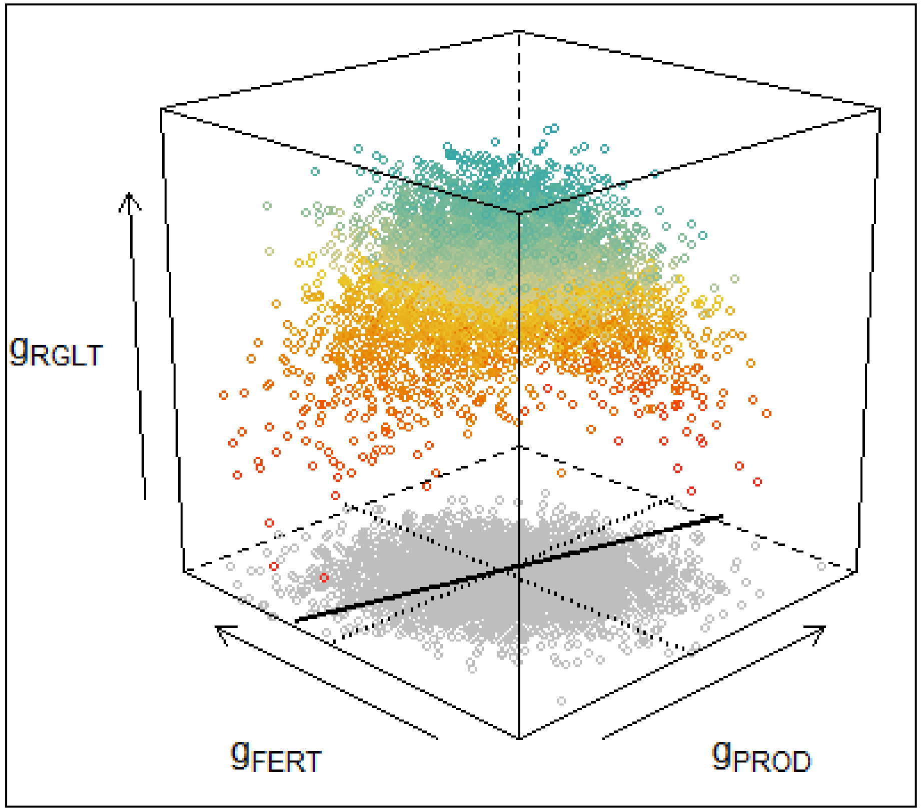


Genetic correlation between antagonistic traits

- I will focus the discussion on the trade-off between production and fertility.



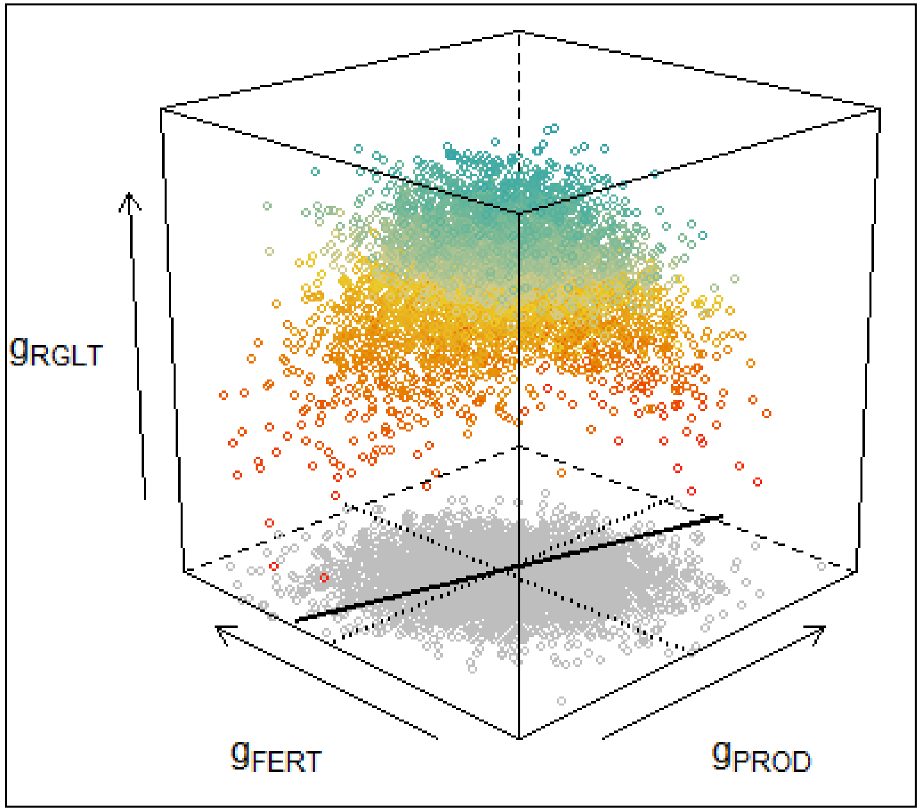
Genetic correlation between antagonistic traits



(simulated data)

- Selection only for production and fertility ignores the latent regulatory trait,
- Genetic progress is achieved for the two traits of interest (PROD + FERT) anyway,
- Ignoring the latent regulatory trait may negatively impact other traits not currently evaluated.

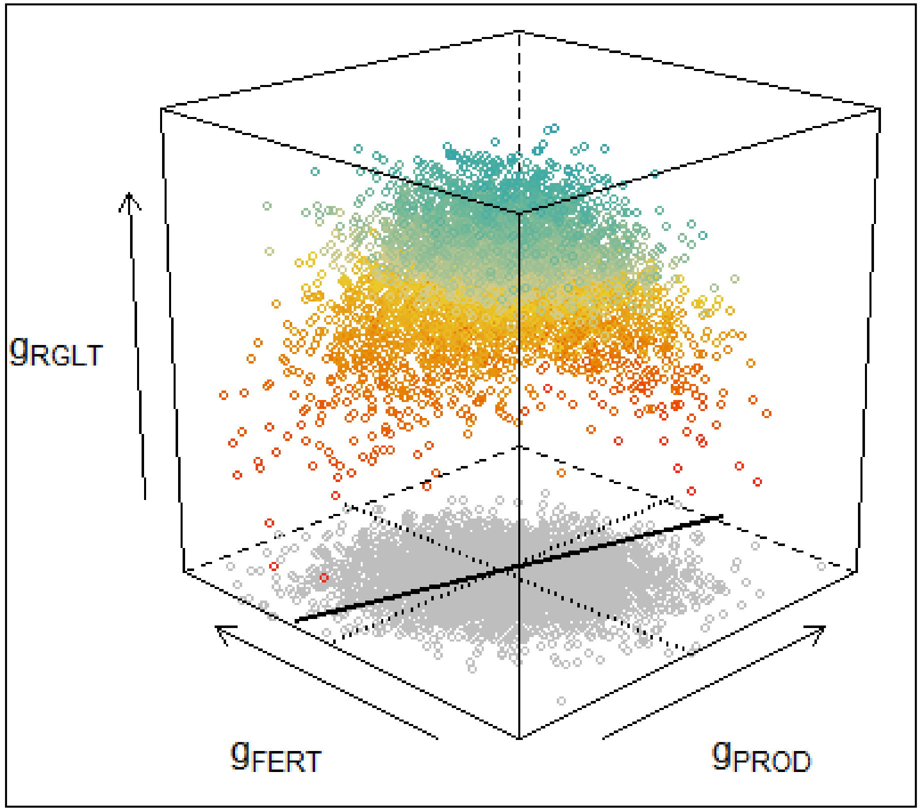
Genetic correlation between antagonistic traits



(simulated data)

- Selection only for production and fertility ignores the latent regulatory trait,
- Genetic progress is achieved for the two traits of interest (PROD + FERT) anyway,
- Ignoring the latent regulatory trait may negatively impact other traits not currently evaluated.

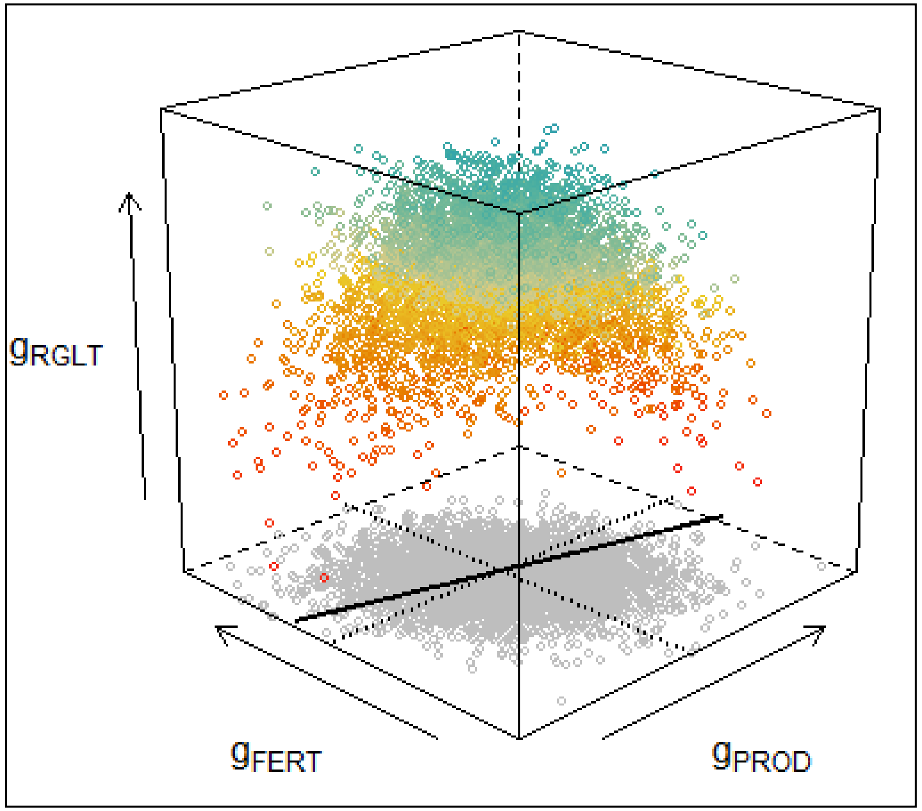
Genetic correlation between antagonistic traits



(simulated data)

- Selection only for production and fertility ignores the latent regulatory trait,
- Genetic progress is achieved for the two traits of interest (PROD + FERT) anyway,
- Ignoring the latent regulatory trait may negatively impact other traits not currently evaluated.

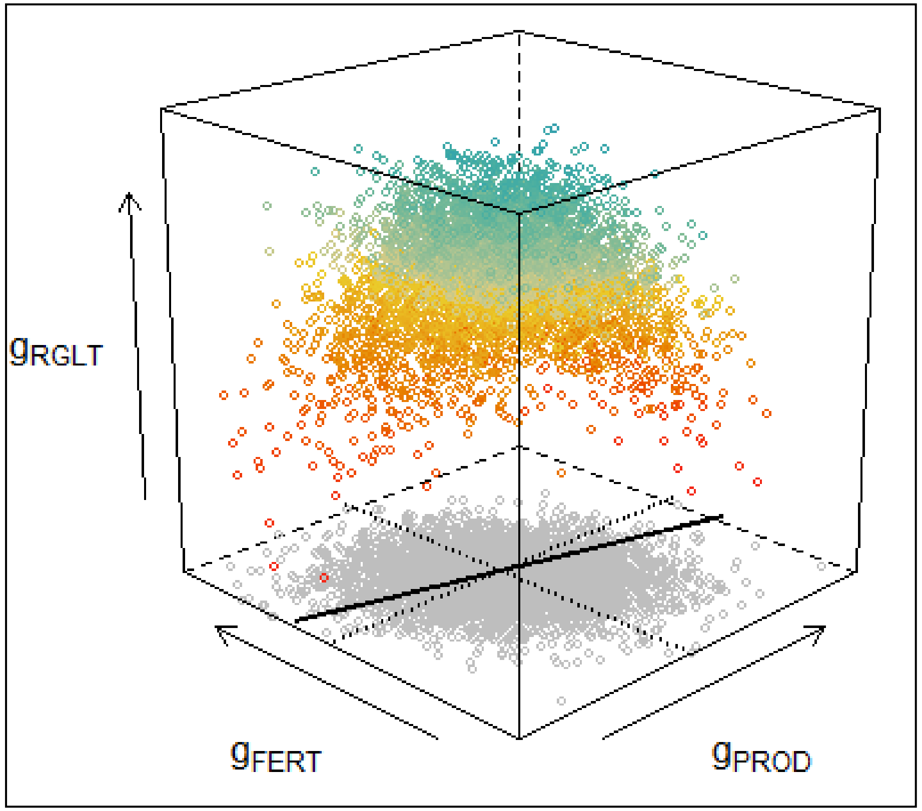
Genetic correlation between antagonistic traits



(simulated data)

- Selection only for production and fertility ignores the latent regulatory trait,
- Genetic progress is achieved for the two traits of interest (PROD + FERT) anyway,
- Ignoring the latent regulatory trait may negatively impact other traits not currently evaluated.

Genetic correlation between antagonistic traits

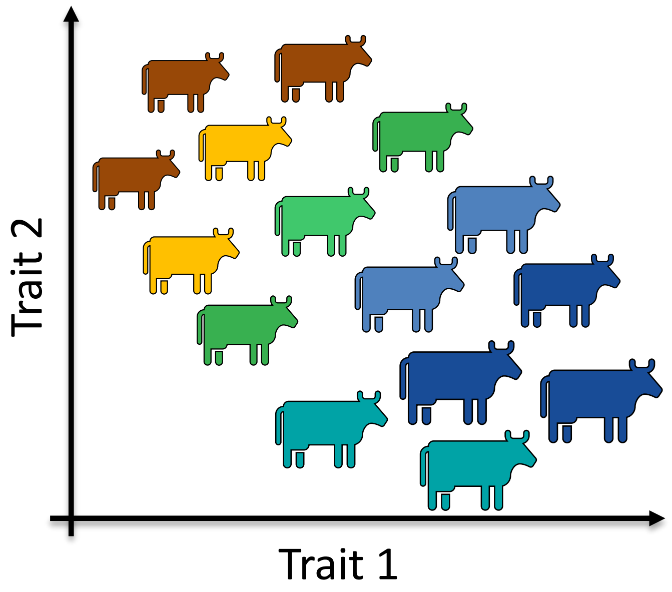


(simulated data)

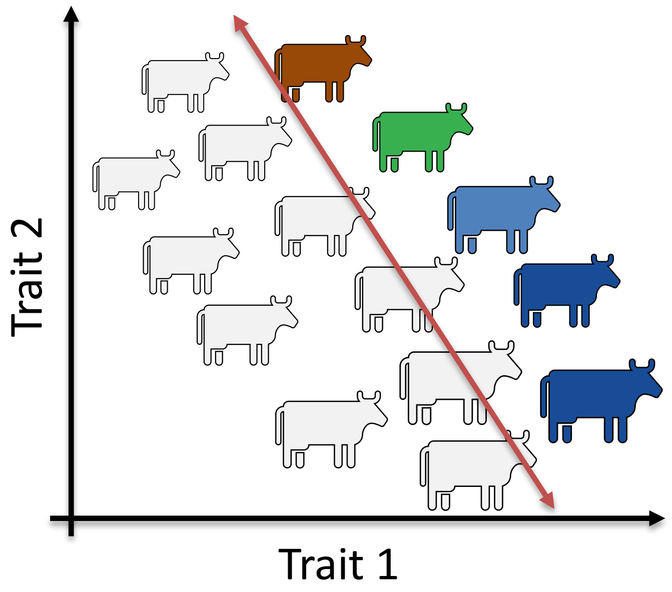
- Selection only for production and fertility ignores the latent regulatory trait,
- Genetic progress is achieved for the two traits of interest (PROD + FERT) anyway,
- Ignoring the latent regulatory trait may negatively impact other traits not currently evaluated.

One way to take into account the latent regulatory trait is to select for animals with less negative correlation.

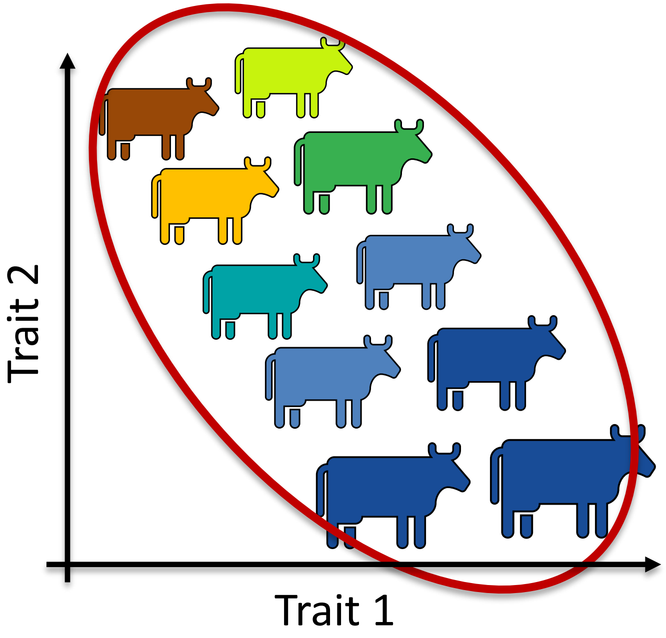
Increasing diversity by accounting for the genetic correlation



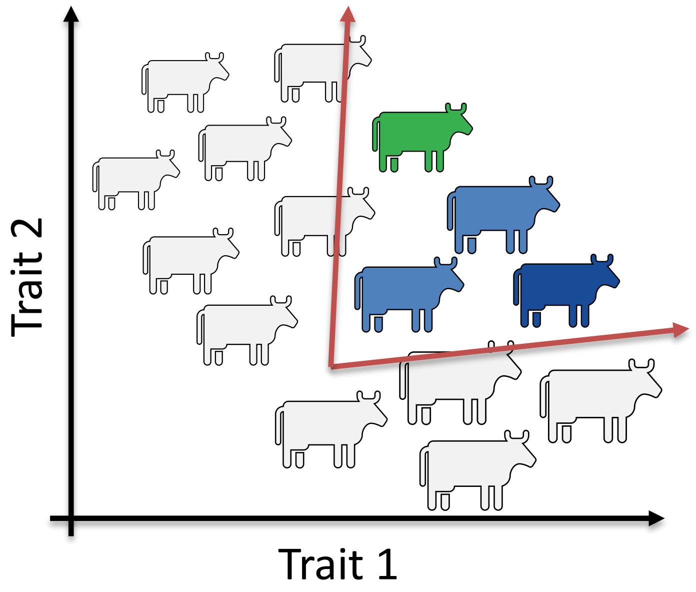
Increasing diversity by accounting for the genetic correlation



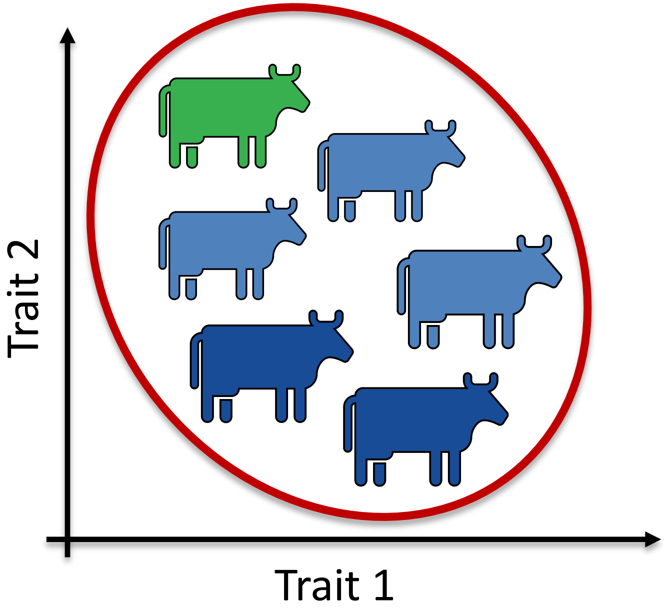
Genetic progress for both traits, but at the cost of an intensified negative correlation.



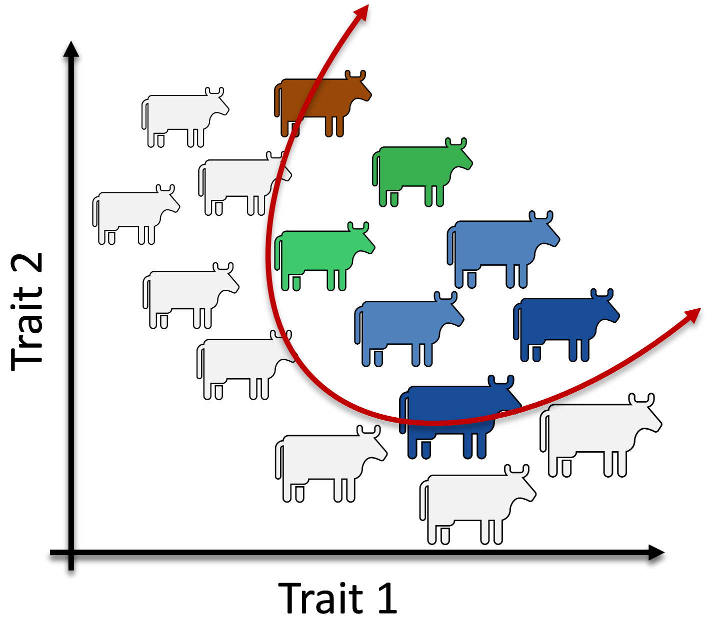
Increasing diversity by accounting for the genetic correlation



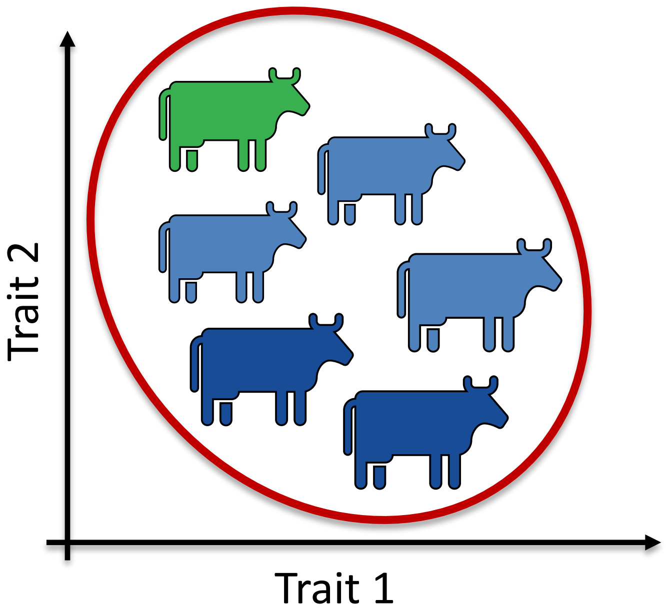
Genetic progress for both traits, without intensifying the negative correlation.



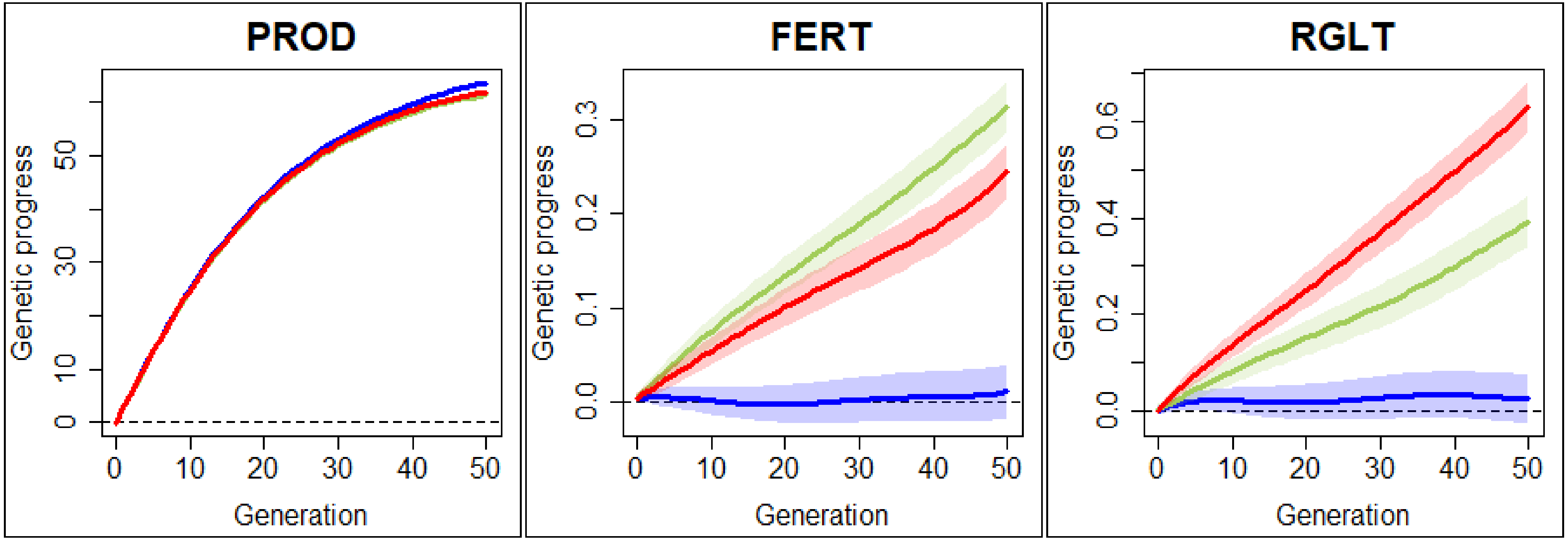
Increasing diversity by accounting for the genetic correlation



Genetic progress for both traits, without intensifying the negative correlation.



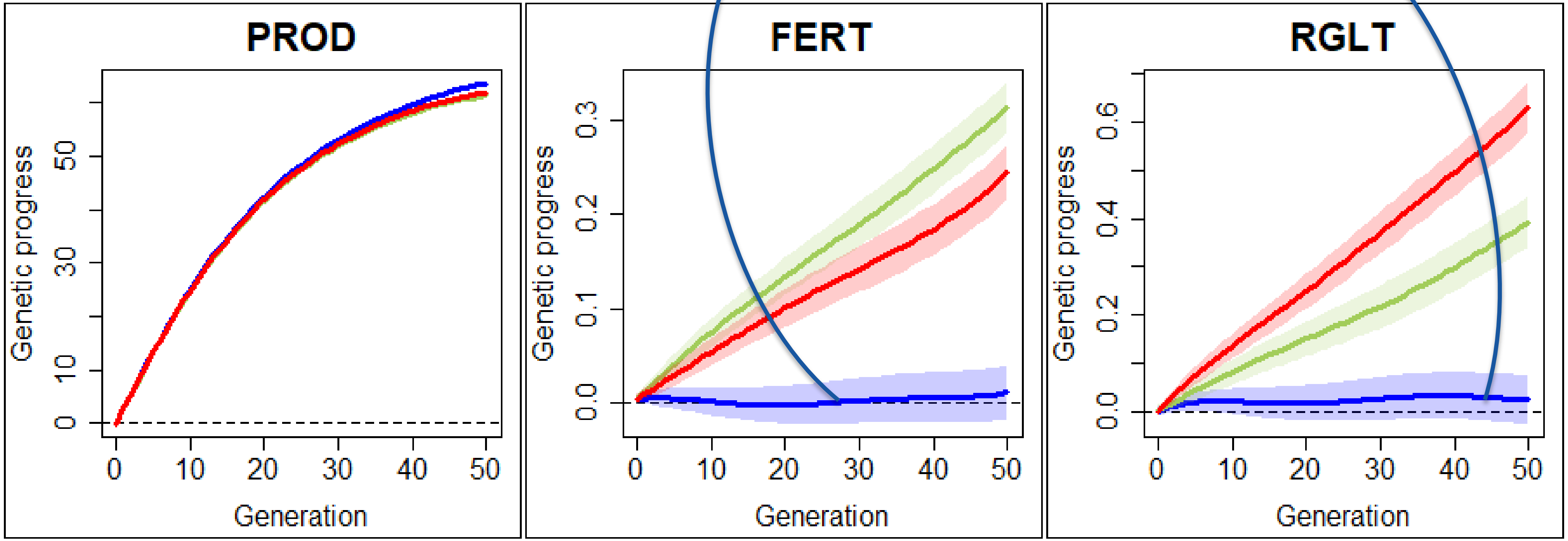
Simulation results



100% PROD
80% PROD + 20% FERT
80% PROD + 10% FERT + 10% RGLT (via genetic correlation)

Simulation results

Selection for PROD alone results in no progress for FERT and RGLT



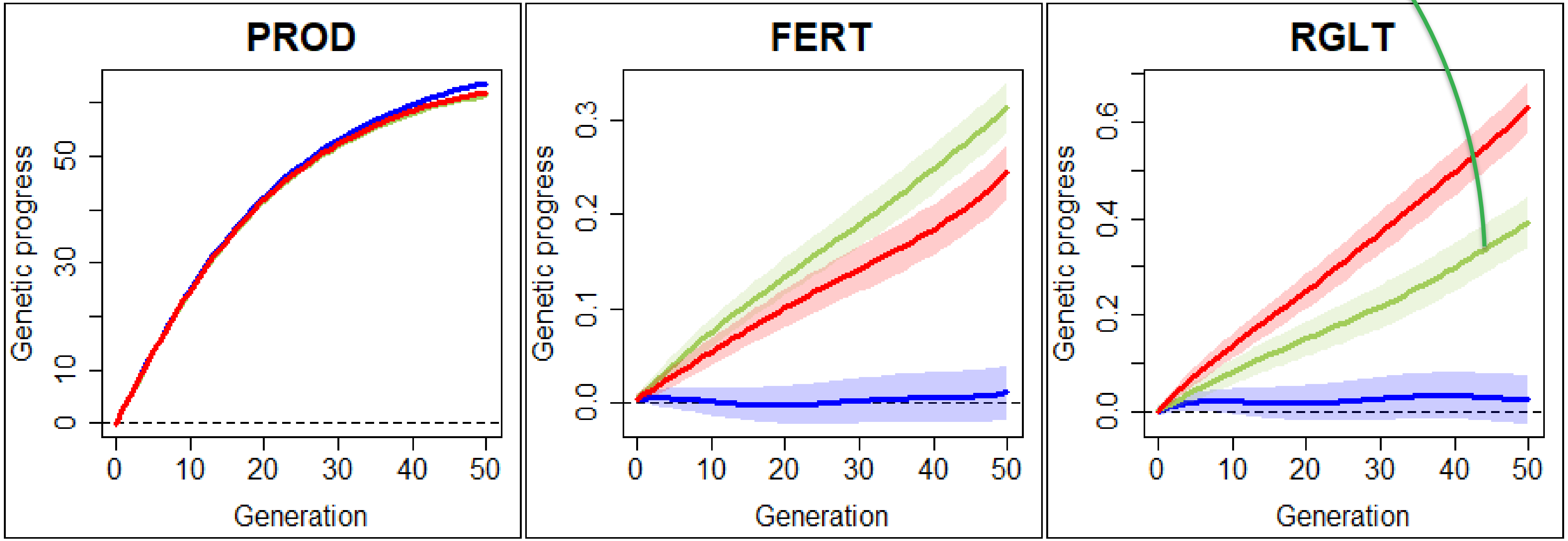
100% PROD

80% PROD + 20% FERT

80% PROD + 10% FERT + 10% RGLT (via genetic correlation)

Simulation results

Selection for PROD and FERT results in a progress for RGLT



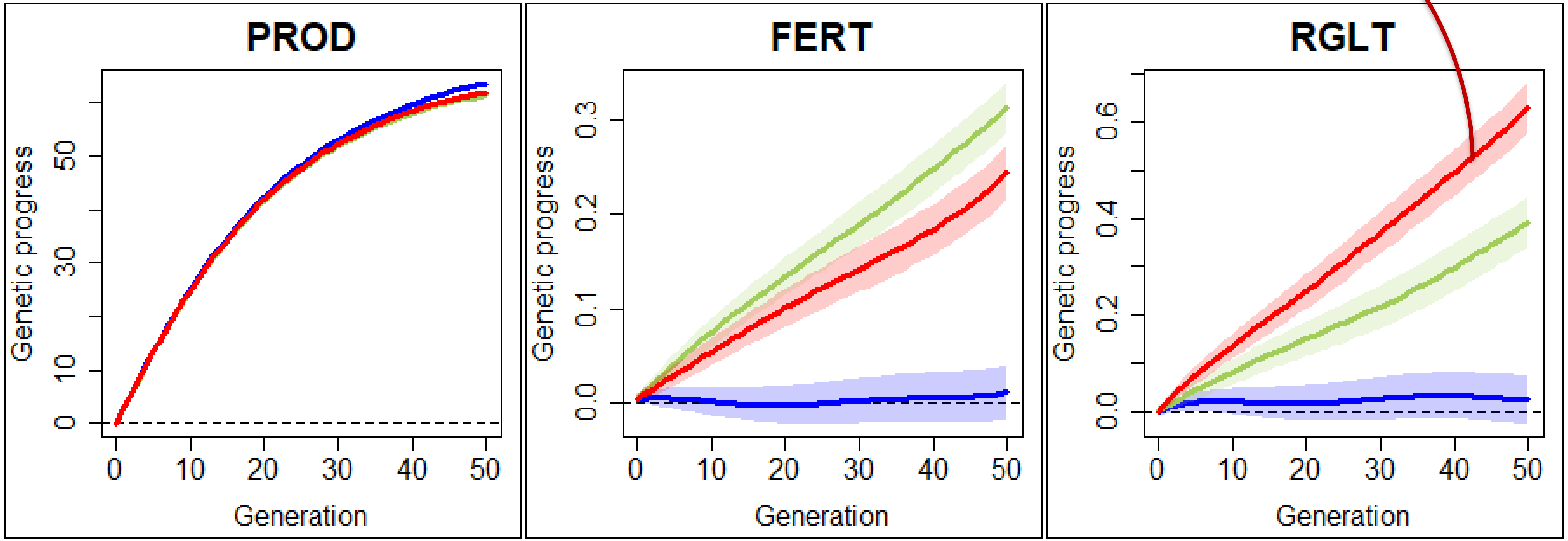
100% PROD

80% PROD + 20% FERT

80% PROD + 10% FERT + 10% RGLT (via genetic correlation)

Simulation results

The inclusion of RGLT in the selection index (although with a small %) resulted in a great gain for this trait!



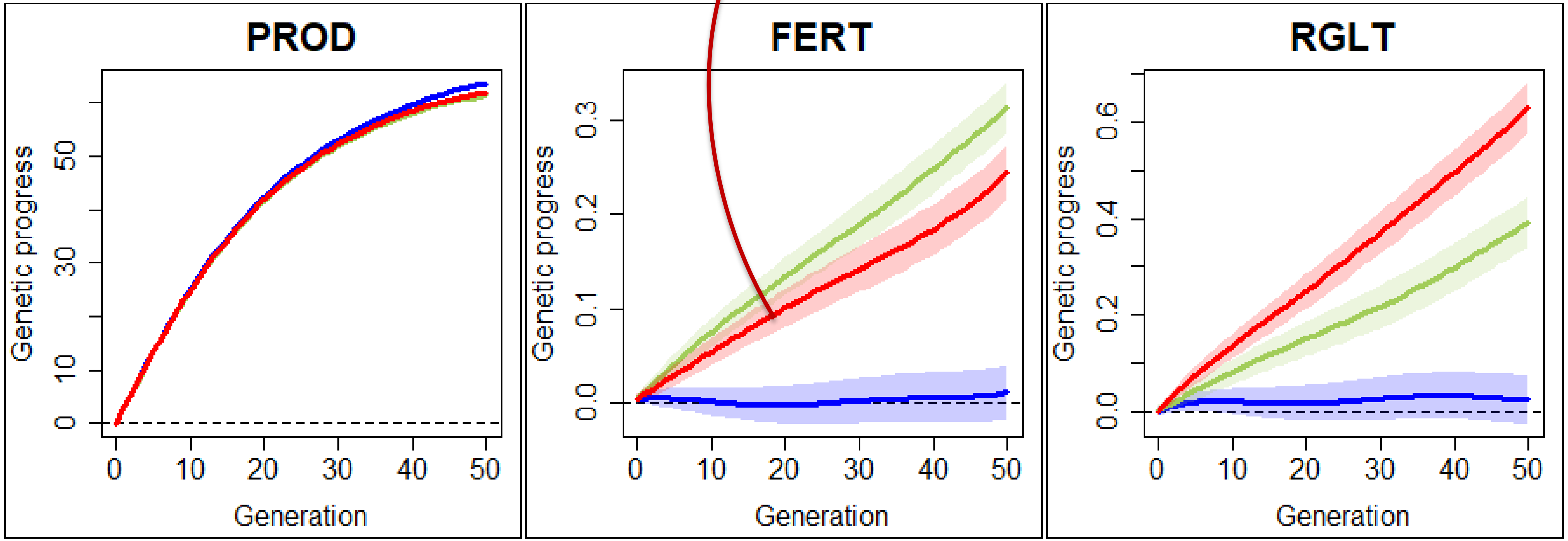
100% PROD

80% PROD + 20% FERT

80% PROD + 10% FERT + 10% RGLT (via genetic correlation)

Simulation results

While progress of FERT decreased, its % in the index was halved, and the decrease in gain was not equivalent to this half!



100% PROD
80% PROD + 20% FERT
80% PROD + 10% FERT + 10% RGLT (via genetic correlation)

Conclusions

- We hypothesize that negative genetic correlations are not only quantitative, but also a result of a physiological regulation (latent trait),
- When accounting for individualized genetic correlations:
  - Traits trade-offs can be better managed,
  - Greater genetic diversity is maintained,
  - The latent regulatory trait achieves greater genetic progress,
- A greater improvement of the regulatory trait will also positively impact the many other traits involved in a breeding program, that are associated to this latent trait.

Conclusions

- We hypothesize that negative genetic correlations are not only quantitative, but also a result of a physiological regulation (latent trait),
- When accounting for individualized genetic correlations:
  - Traits trade-offs can be better managed,
  - Greater genetic diversity is maintained,
  - The latent regulatory trait achieves greater genetic progress,
- A greater improvement of the regulatory trait will also positively impact the many other traits involved in a breeding program, that are associated to this latent trait.

Conclusions

- We hypothesize that negative genetic correlations are not only quantitative, but also a result of a physiological regulation (latent trait),
- When accounting for individualized genetic correlations:
  - Traits trade-offs can be better managed,
  - Greater genetic diversity is maintained,
  - The latent regulatory trait achieves greater genetic progress,
- A greater improvement of the regulatory trait will also positively impact the many other traits involved in a breeding program, that are associated to this latent trait.

Conclusions

- We hypothesize that negative genetic correlations are not only quantitative, but also a result of a physiological regulation (latent trait),
- When accounting for individualized genetic correlations:
  - Traits trade-offs can be better managed,
  - Greater genetic diversity is maintained,
  - The latent regulatory trait achieves greater genetic progress,
- A greater improvement of the regulatory trait will also positively impact the many other traits involved in a breeding program, that are associated to this latent trait.

THANK YOU!

www.rumigen.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000226