Indirect genetic effects in fish breeding programs

Gabriel Rovere & Florence Phocas

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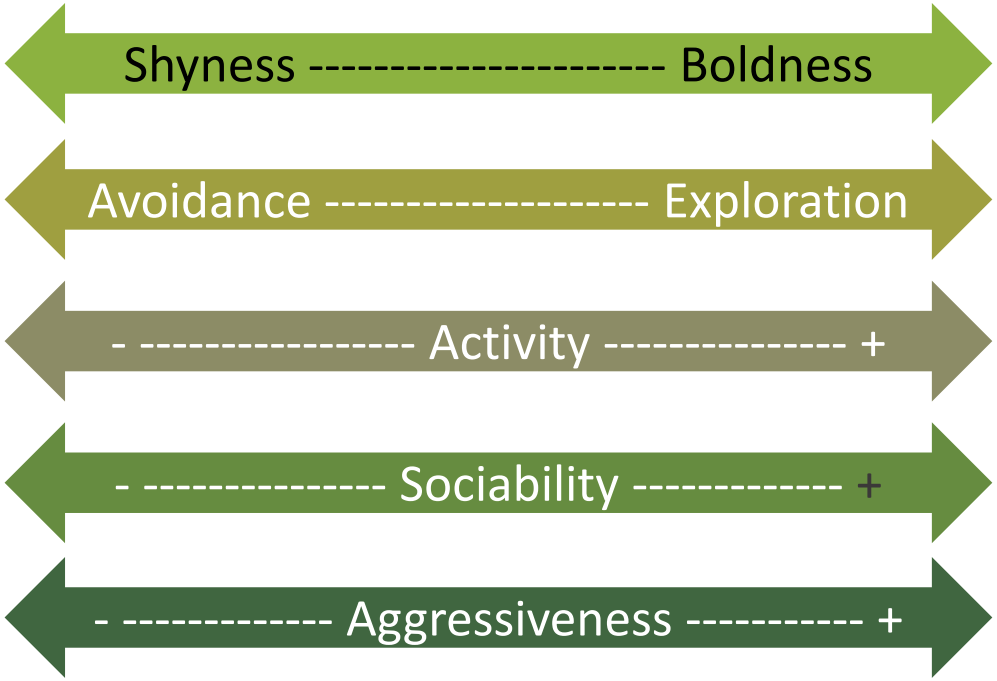
Introduction

- Social interactions are common in animals in wild and farmed animal populations.

- In farming species, social interaction can affect traits of economic relevance and diminish the expected genetic gain of breeding programs.

- In aquaculture populations, competition for feed and the formation of social hierarchies is observed and can affect phenotypic variance.

Personality traits reported



Body size ~ indicator of competition

Social interactions

Cannibalism

Competition

Cooperation

- Fitness
- Foraging
- Defense

Rainbow trout

Boldness

Boldness ~ Exploration(+)

Aggressivity ~ Exploration(+)

Objective

- To simulate breeding schemes considering that social interactions affect a trait of interest in Rainbow trout.

- Account for different frequency and intensity of social interactions by individual

Simulation

Base Population

200 individuals

	Variances			
Traits	Phenotypic	Additive	Social Interactions	Direct Environment
Phenotype observed	3	1	0.3	1.7
Phenotype performer	3	1	0	2
Phenotype receiver	3	1	0	2

Size	200 parents
Additive Genetic effects • Observed trait (Y) • Personality trait - Performer (P) • Personality trait - Receiver (R)	$\begin{bmatrix} A_Y \\ A_P \\ A_R \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma^2_{A_Y} = 1 & 0 & 0 \\ 0 & \sigma^2_{A_P} = 1 & 0 \\ 0 & 0 & \sigma^2_{A_R} = 1 \end{bmatrix}\right.$
Environmental effects • Production Trait (Y) • Personality Performer trait (P) • Personality Receiver trait (R)	$\begin{bmatrix} E_Y \\ E_P \\ E_R \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma^2_{E_Y} = 1.7 & 0 & 0 \\ 0 & \sigma^2_{E_P} = 2 & 0 \\ 0 & 0 & \sigma^2_{E_R} = 2 \end{bmatrix}\right.$
Phenotypes • Observed Trait (Y) • Personality Performer trait (P) • Personality Receiver trait (R)	$\begin{bmatrix} P_Y \\ P_P \\ P_R \end{bmatrix} = \begin{bmatrix} A_Y \\ A_P \\ A_R \end{bmatrix} + \begin{bmatrix} E_Y \\ E_P \\ E_R \end{bmatrix} + \begin{bmatrix} SI \\ 0 \\ 0 \end{bmatrix}$

Social Interactions

2 steps:

1) The probability of interaction between individuals

2) The effect of social interaction on the trait of interest

1) Probability that two individuals interact

a) Probability of physical proximity

3 random coordinates

$$D_{i,j} = Euclidean\ distance\ (Location_{(x,y,z)_i}, Location_{(x,y,z)_j})/\max(D)$$

** Corrected by density when needed*

b) Probability of interaction based on the personality traits

$$p_{ij} = \frac{1}{2}\ logit^{-1}\ (P_{P_i} + P_{R_j})*(P_{Y_i} - P_{Y_j})\ +\ \frac{1}{2} logit^{-1}(P_{R_i} + P_{P_j})*(P_{Y_j} - P_{Y_i})$$

c) Probability that the social interaction actually happens

$$p_{ij_{happen}} \sim Bernoulli(p_{ij})$$

2) Effect of SI on the trait of interest

$$P_{Y_{new,i}} = P_{Y_i} + b_{i,j} * (P_{Y_j} - P_{Y_i})$$

Result for i interacting with j

$$b_{i,j} = \bar{b} + (P_{P_i} + P_{R_j})$$

$\bar{b}$ → Population parameter

-1 Competitive | Neutral | Collaborative +1

$$P_{Y_{new,i}} = P_{Y_i} + \sum b_{i,j} * (P_{Y_j} - P_{Y_i})$$

Marjanovic et al. 2018

Scenarios

$$\sigma^2_{SI} \begin{cases} 0.10 * \sigma^2_{P_Y} \\ 0 * \sigma^2_{P_Y} \end{cases}$$

$\bar{b}$ → Population parameter

-0.5	Competitive
0	Neutral
+0.5	Collaborative

100 repetitions

10 generations

Mating Groups

1

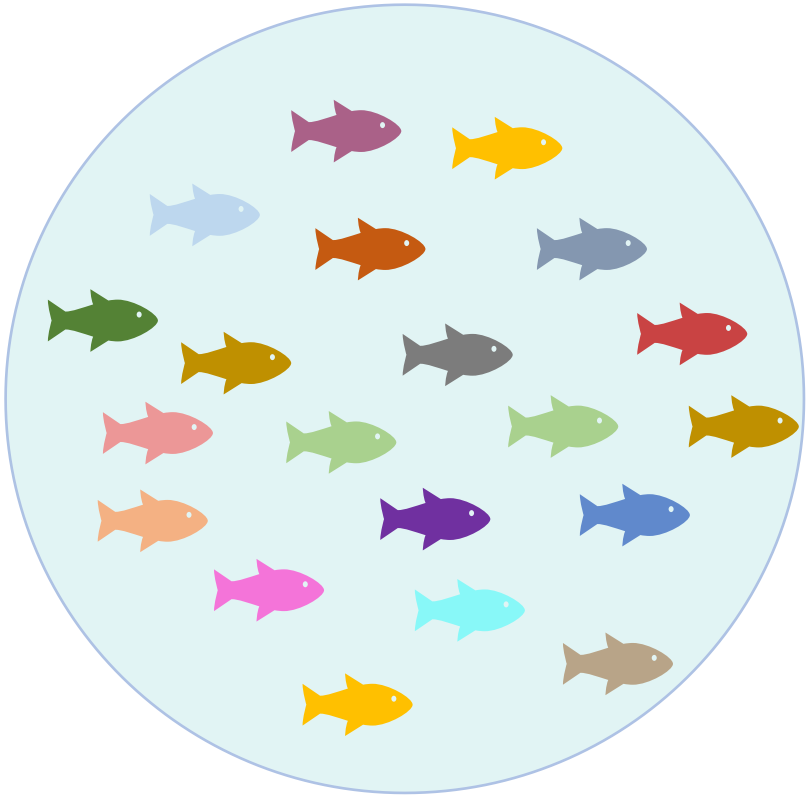
10 x 10

200 Parents

10

10 x 10

2,000 Individuals



200 random parents

Base Population

Random mating 5 generations

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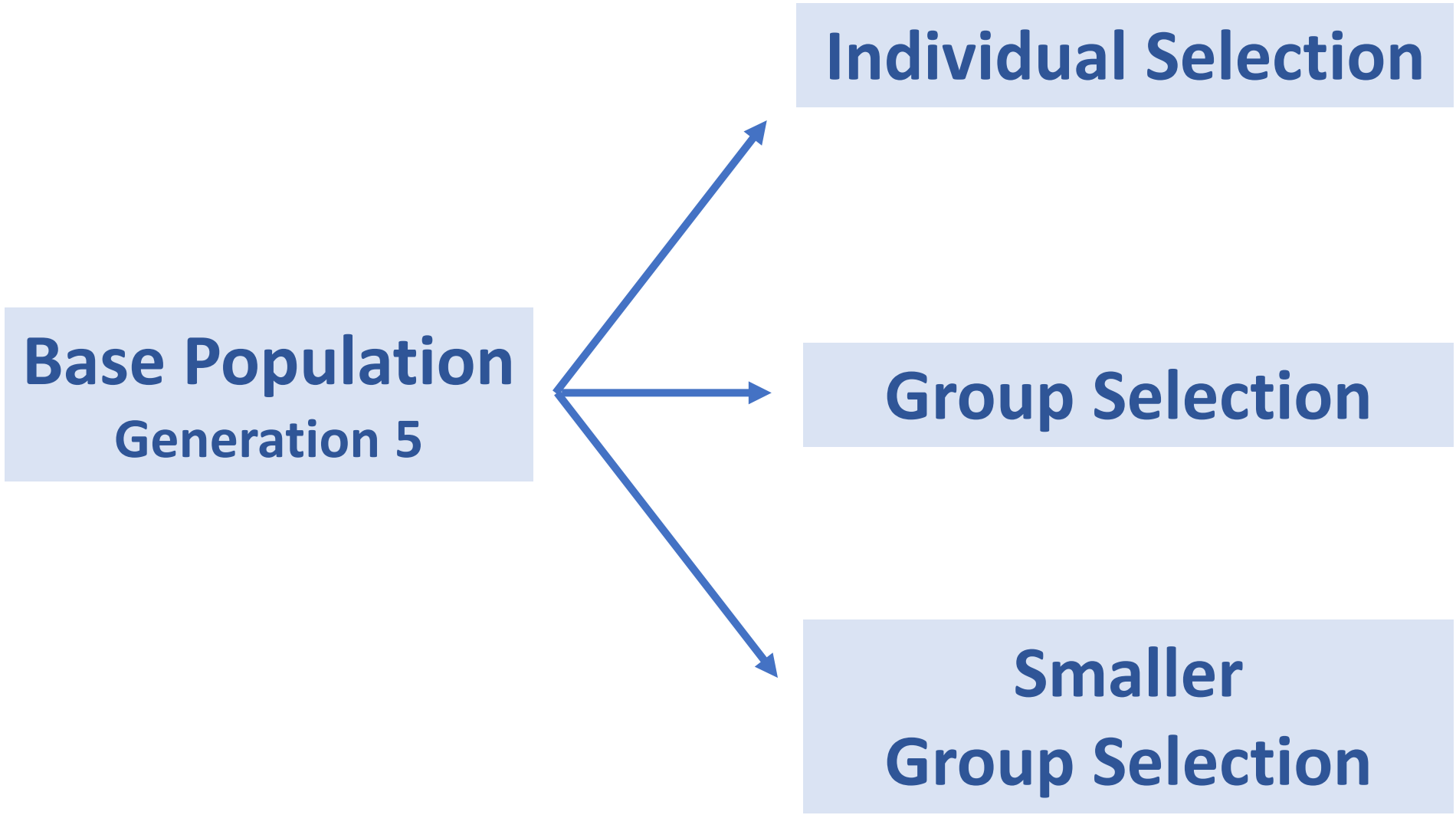

Individual Selection
Base Population
Generation 5
Group Selection
Smaller
Group Selection

Mating Groups

1

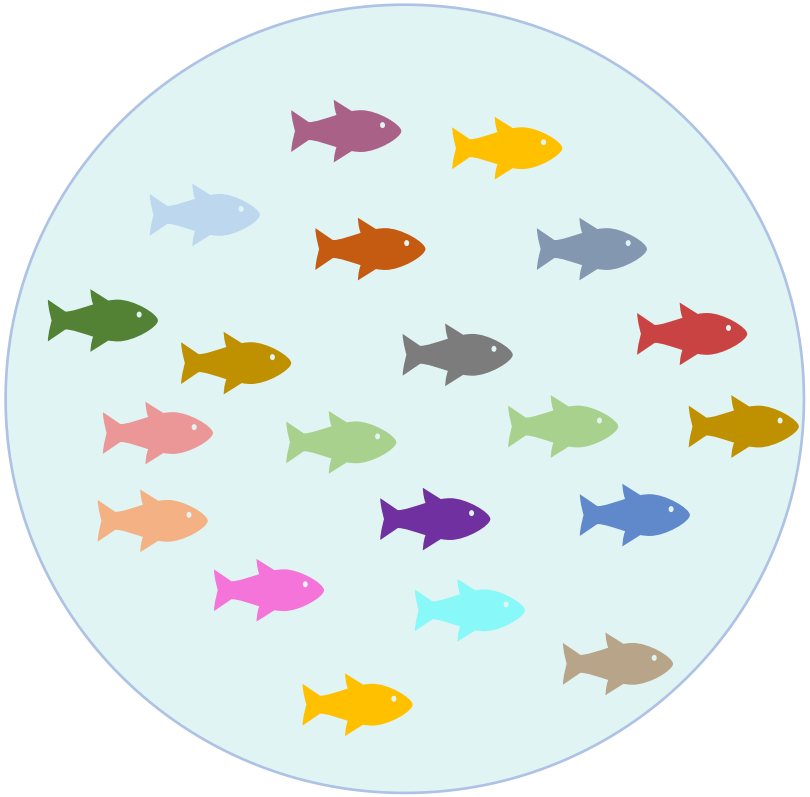
10 x 10

200 Parents

10

10 x 10

2,000 Individuals



Selection best 200

Individual Selection

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Mating Groups

1

10 x 10

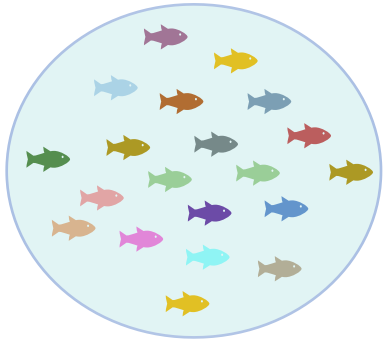
200 Parents

10

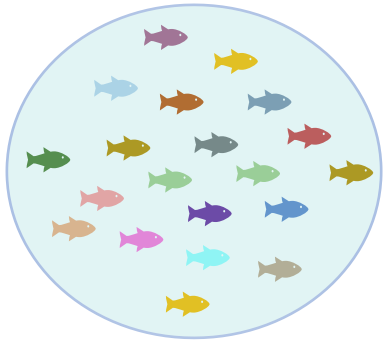
10 x 10

2,000 Individuals

200 Individuals



200 Individuals



Selection of best group

Group Selection

Mating Groups

1

10 x 10

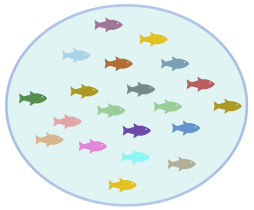
200 Parents

10

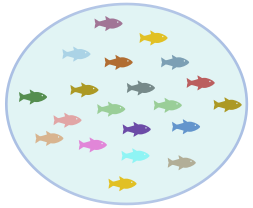
10 x 10

2,000 Individuals

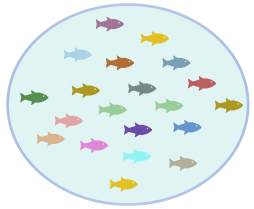
100 Individuals 1



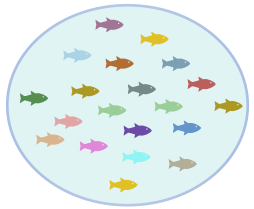
100 Individuals 2



100 Individuals 19



100 Individuals 20



Selection of 2 best groups

Smaller Group Selection

Results

With and without social interactions effect

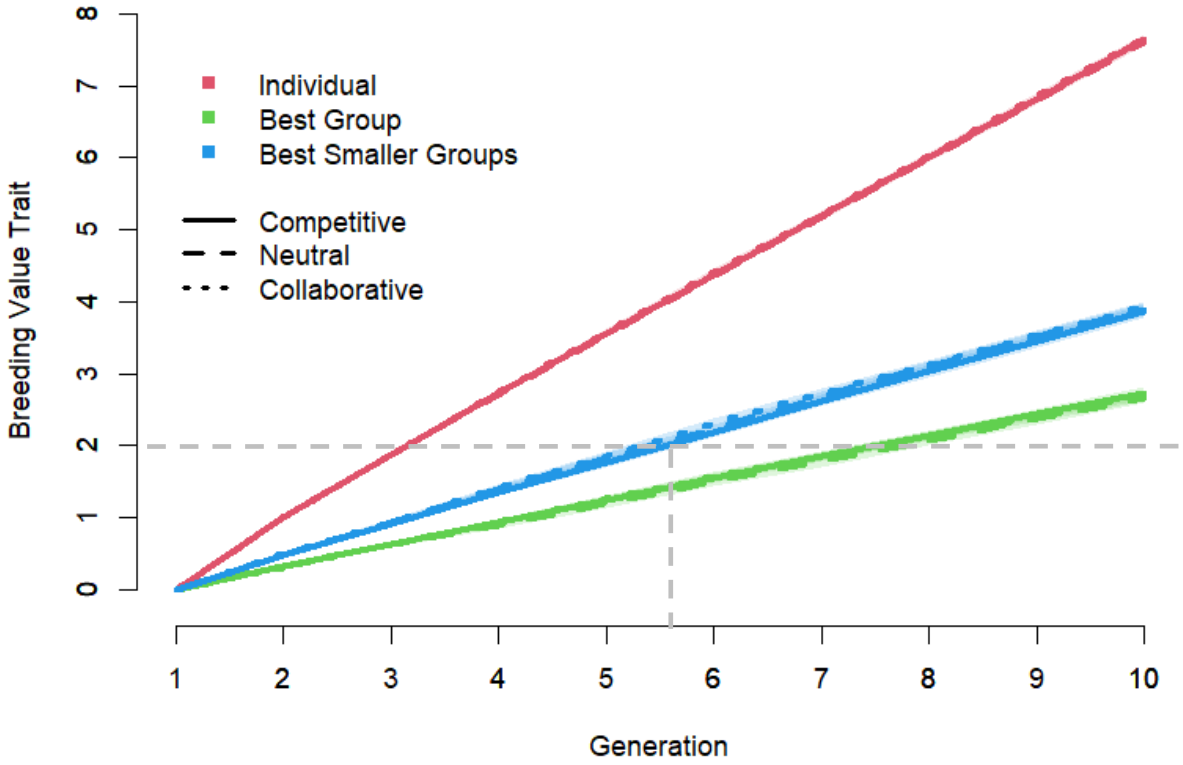
Social Interactions -> 0% phenotypic variance of observed phenotype

versus

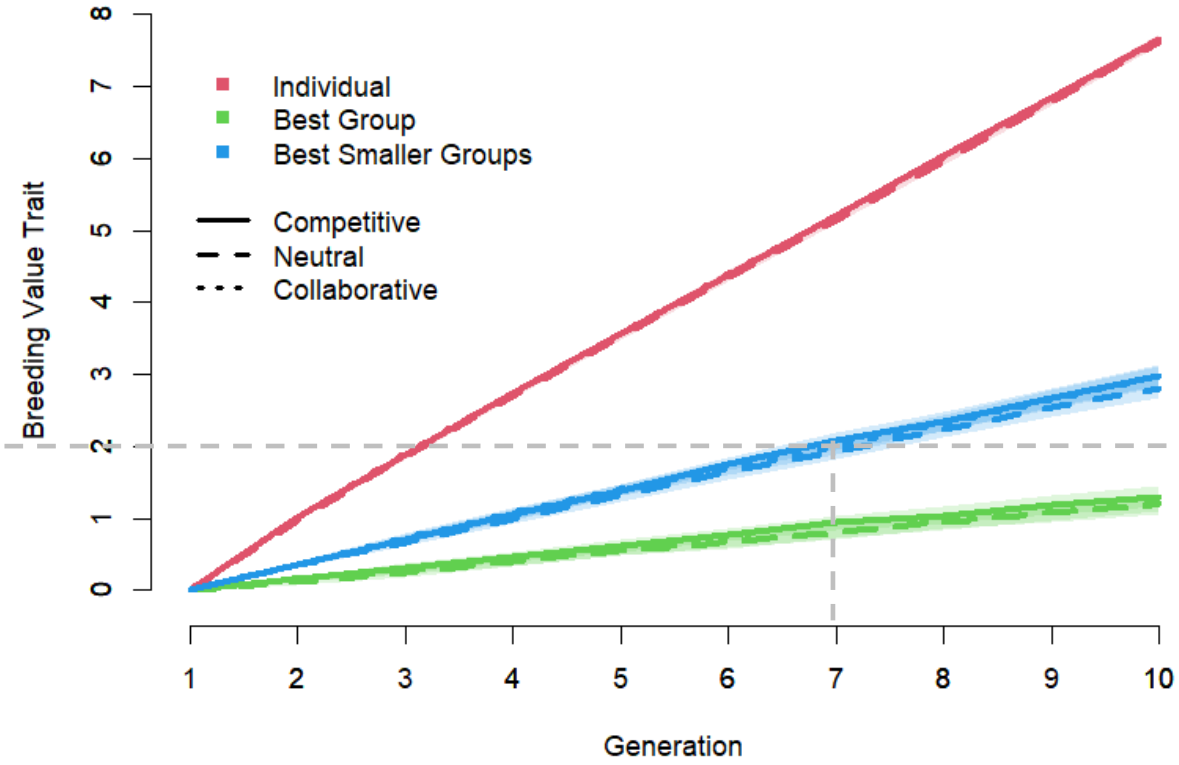
Social Interactions -> 10% phenotypic variance of observed phenotype

Breeding Values Trait observed

Social Interactions = **0 %** of the Phenotypic Variance

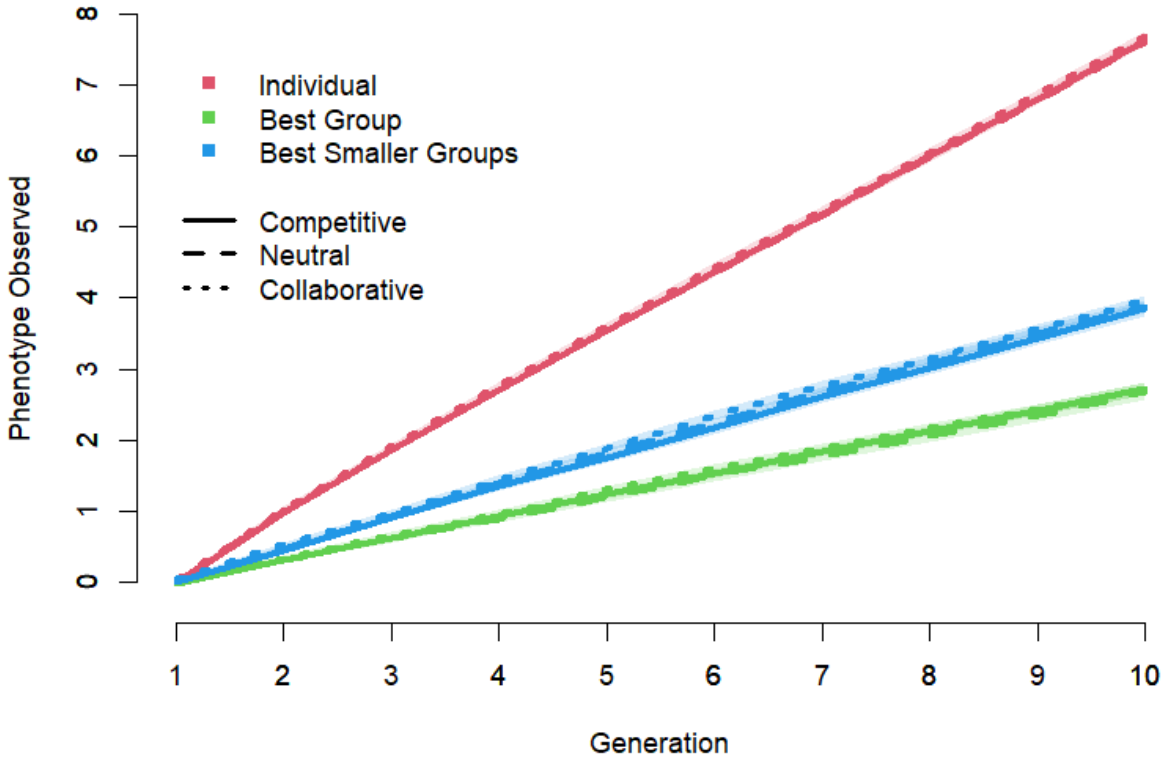


Social Interactions = **10 %** of the Phenotypic Variance

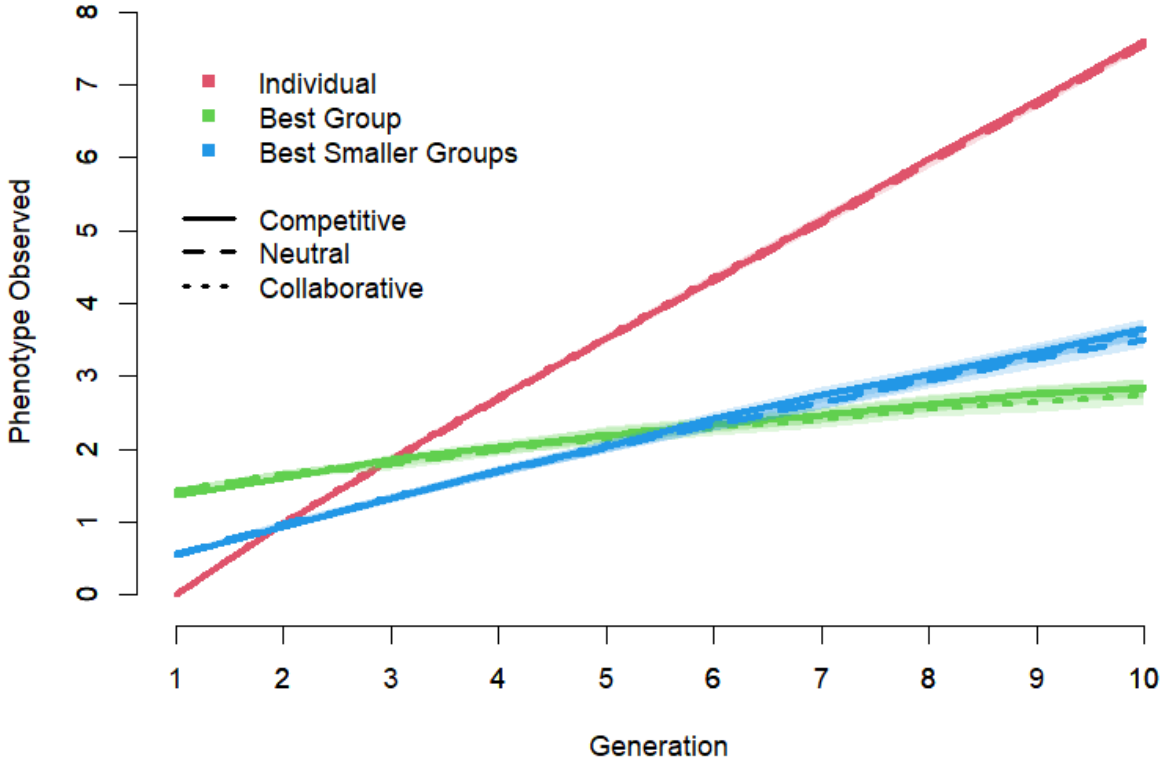


Phenotype observed

Social Interactions = **0 %** of the Phenotypic Variance

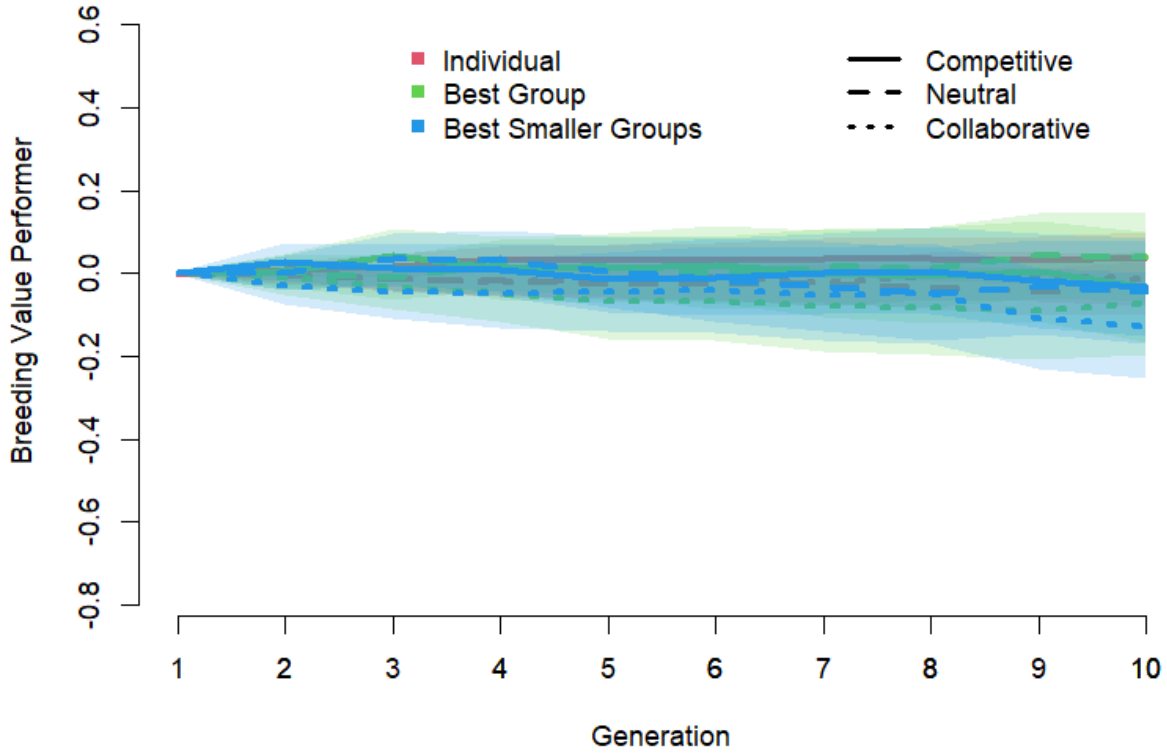


Social Interactions = **10 %** of the Phenotypic Variance

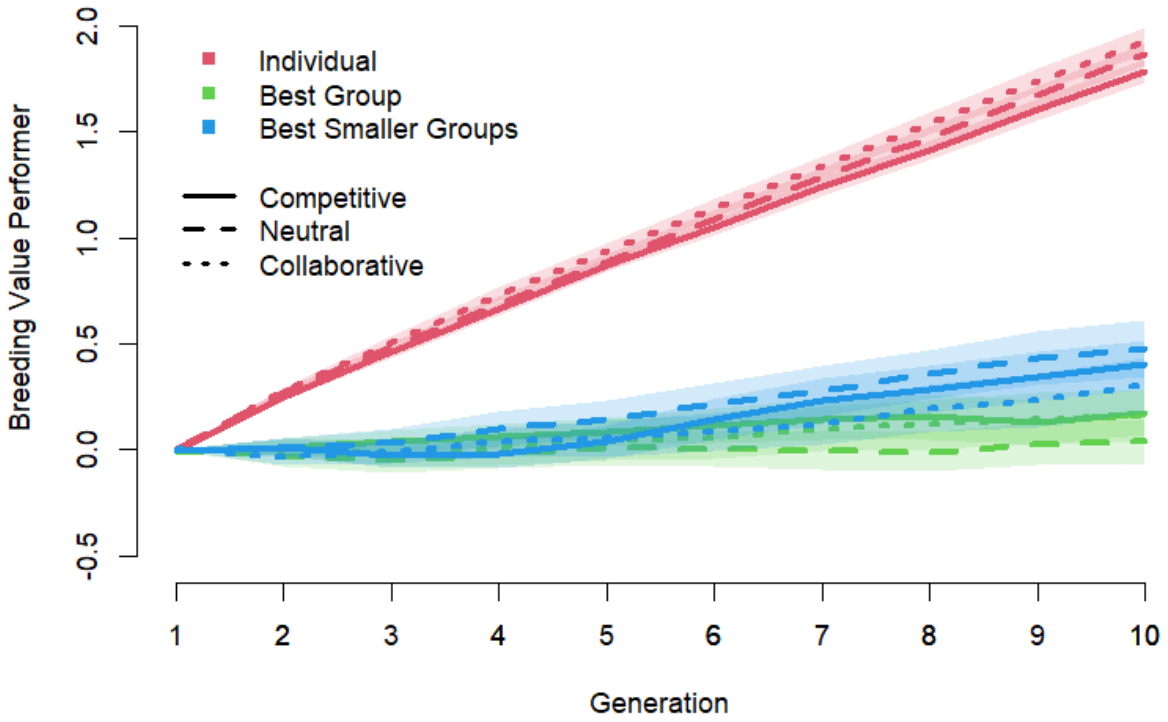


Breeding Values Personality Performer

Social Interactions = **0 %** of the Phenotypic Variance

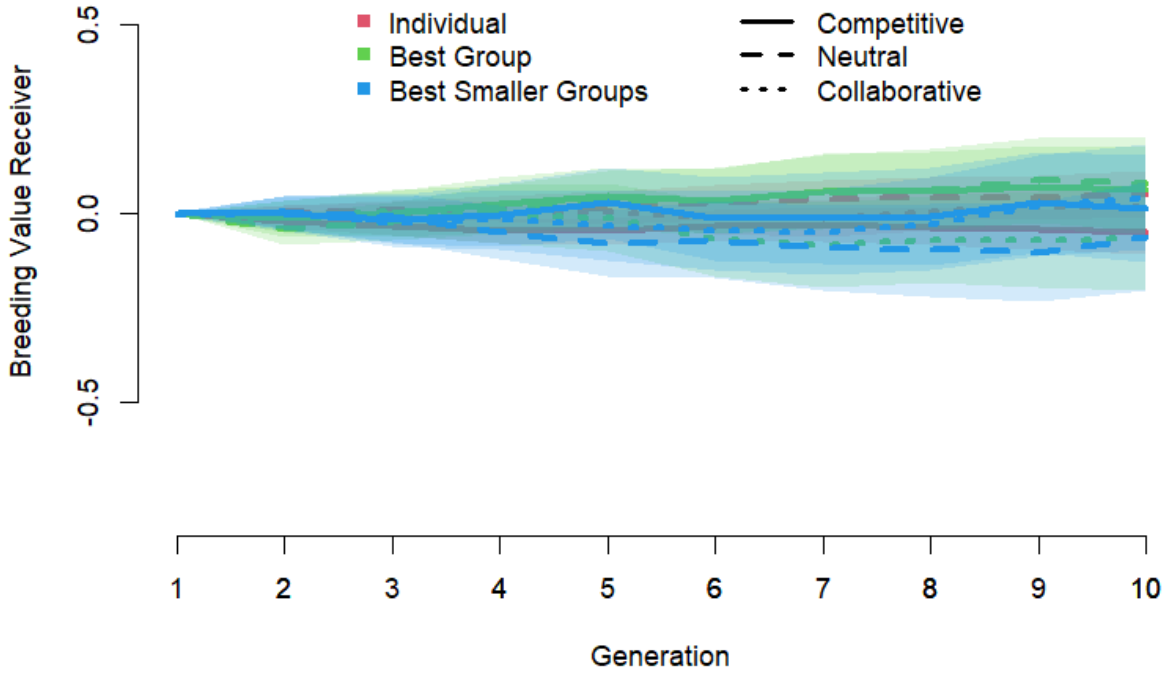


Social Interactions = **10 %** of the Phenotypic Variance

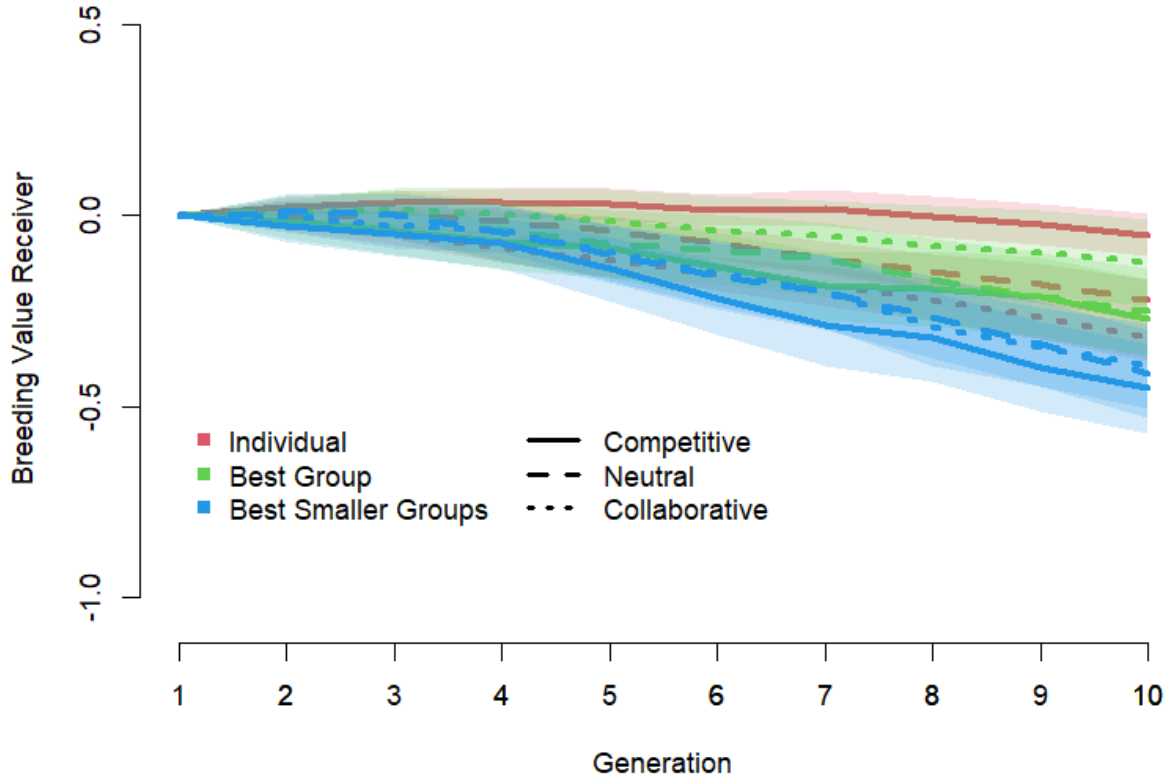


Breeding Values Personality Receiver

Social Interactions = **0 %** of the Phenotypic Variance



Social Interactions = **10 %** of the Phenotypic Variance



Final considerations

1. In the long run (10 gen) Individual Selection achieved a better performance.
2. In the short term (3 gen) Group Selection showed better results
3. With Individual Selection, personality trait “perfomer” increase more markedly.

In competitive environments, it can increase aggressiveness, and the consequences should be further analyzed.

Thank you for your attention!

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