Competition meets canalization: Unravelling the relationship between social interactions and inherited variability

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EGS ABG

Erasmus Mundus

"All of life is social" *Steven A. Frank*

- Everywhere in the nature individuals interact
- Domestic populations
- Negative social interactions - harm welfare and health; reduce productivity
- Important for animal breeding and aquaculture
- Social interactions contribute to heritable variation in the trait

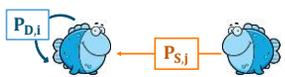Feather pecking in **chickens**　　Tail biting in **pigs**　　Competition in **aquaculture**

Indirect Genetic Effects (IGE)

- Expression of traits

$$P = A + E$$

- With social interactions

$$P = A + E_n + E_S$$

$$P_i = A_{D,i} + E_{D,i} + A_{S,j} + E_{S,j}$$

Direct Genetic Effect of self　　　Indirect Genetic Effects of social partners

$P_{D,i}$　　$P_{S,j}$

- Other approach

$$P_i = A_i + E_i + \psi P_j$$

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IGEs and variability

- In **aquaculture** species and some **plants** **competition inflates variation**
- IGEs and inherited variability are related via competition

Competition vs. cooperation

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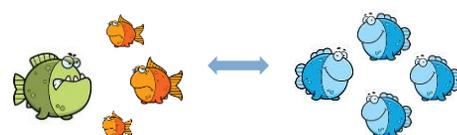
Examples from plant breeding - rice

- Selection for higher productivity ➡ less competition, more uniformity

Wild type vs. domestic

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Inherited variability

- Variability of trait values of a genotype
- Quantitative genetic trait
- Genetic heterogeneity of environmental (residual) variance
- Desirable to improve by genetic selection
- Empirical evidence – **genetic variation** in Var(E)
- Differential response to small environmental fluctuations

Family A	Family B
More variation	Less variation

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Can inherited variability be explained by IGEs?

- Indications of underlying genetic relationship
- IGEs may be an important component of heritable variation in variability
- Understand phenotypic observations
- Models of IGE and inherited variability are not suitable
- **We need QG-model that connects IGE and variability**

Objectives

- Develop **QG - model** that integrates IGEs and inherited variability
- Use **simulations** to evaluate the behavior of the model

Theory

- Behavior of the individual depends on the size of its social partner
- Higher body weight gives competitive advantage
- Model the evolution of body weight over the life of the individuals
- Basic model involving interaction of 2 individuals

$$P_i = A_i + E_i + \psi P_j$$
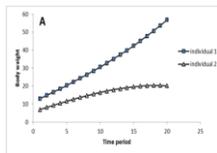
Model

Phenotype – focal individual; BV for growth; Phenotype – group mate

$$P_{t,i} - P_{t-1,i} = \mu_{GR} + A_{GR,i} + b_{ij}\left(P_{t-1,j} - P_{t-1,i}\right)$$

Mean growth rate

Difference in body weight between **j** and **i**

- Regression coefficient
- b is a measure of cooperation
- negative b indicates competition
- positive b indicates cooperation
- b is not a fixed parameter, but specific for every interacting couple

Model

Phenotype – focal individual; BV for growth; Phenotype – group mate

$$P_{t,i} - P_{t-1,i} = \mu_{GR} + A_{GR,i} + b_{ij}\left(P_{t-1,j} - P_{t-1,i}\right)$$

Mean growth rate

Difference in body weight between **j** and **i**

$$b_{ij} \neq b_{ji} \longleftarrow b_{ij} = \bar{b} + A_{D,i} + A_{S,j}$$

Genetic resistance to competition

Genetic cooperation effect
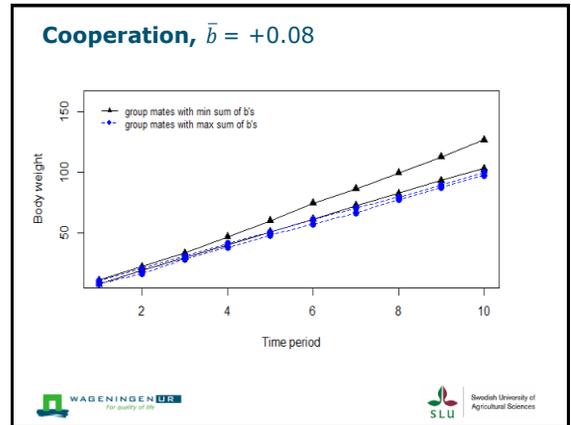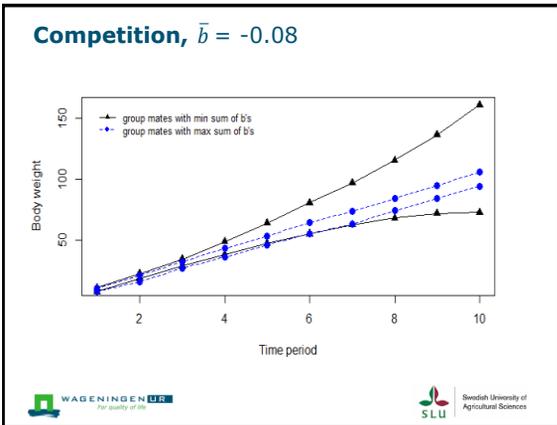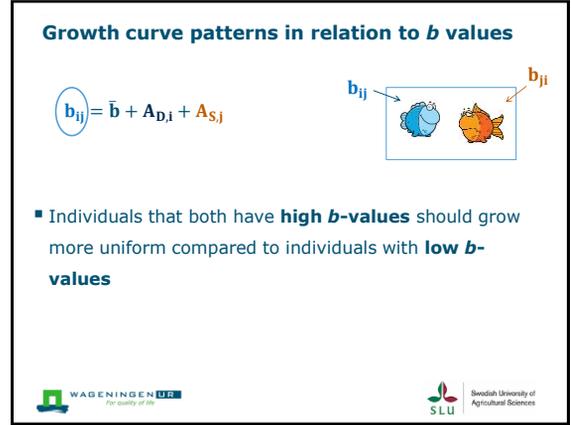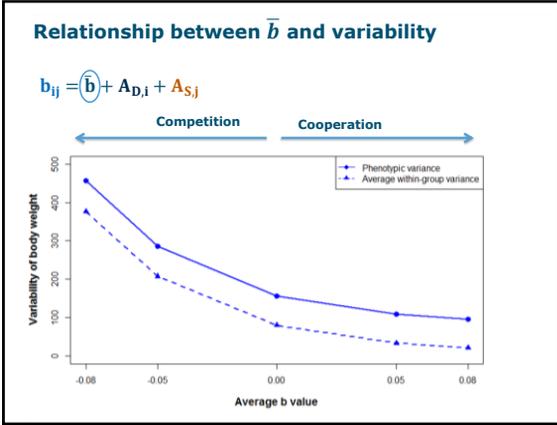
Simulation – part one

Does the model predict observed relationship between competition and variability?

- Genetic and environmental values
- Groups of 2 individuals
- Phenotypes based on equation
- Growth curves 10 time points

$$P_{t,i} - P_{t-1,i} = \mu_{GR} + A_{GR,i} + b_{ij}\left(P_{t-1,j} - P_{t-1,i}\right)$$

Relationship between $\bar{b}$ and variability

$$b_{ij} = \bar{b} + A_{D,i} + A_{S,j}$$

Competition ← → Cooperation

Growth curve patterns in relation to b values

$$b_{ij} = \bar{b} + A_{D,i} + A_{S,j}$$

b_{ij} b_{ji}

- Individuals that both have **high b-values** should grow more uniform compared to individuals with **low b-values**

Competition, $\bar{b} = -0.08$

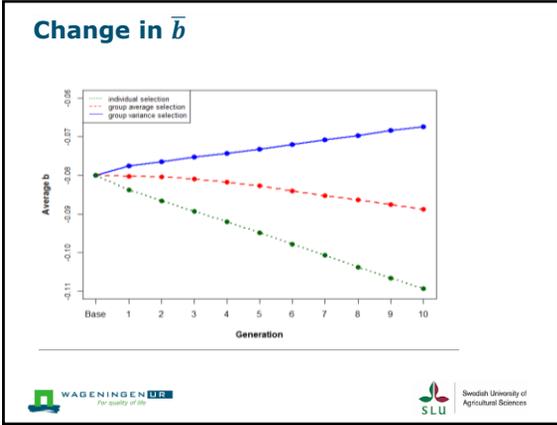## Cooperation, $\bar{b} = +0.08$
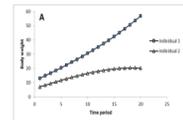
Simulation – part two

How does selection affect variability and average b value?

- 3 types of selection
  - Individual selection on BW
  - Group selection on average BW of 2 group mates
  - Group selection on within-group variance of BW
- 10 generations of selection

Change in variability

3

Change in $\bar{b}$
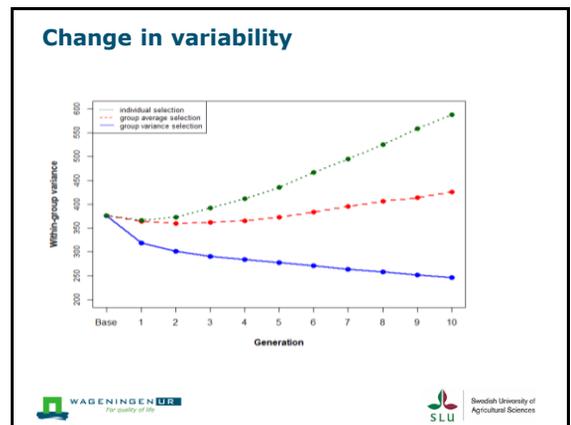
Conclusions

We presented a model that integrates inherited variability with social genetic effects

The model predicts relationships observed in the nature:

- **Competition increases variability**

- **Cooperation decreases variability**

- **Social genetic effect and variability co-evolve as *b* can respond to selection**

Message

Our findings suggest that we may have been overlooking an entire level of genetic variation in variability, the one due to IGEs

Thank you!

| Piter Bijma | Han Mulder | Lars Rönnegård | DJ de Koning |

Follow-up study

- Models for inherited variability
- Variability of sire's offspring
- Correlation **EBV for variability** vs simulated BV for
    - growth
    - Ad for b
    - As for b

$$P_{t,i} - P_{t-1,i} = \mu_{GR} + A_{GR,i} + b_{ij}\left(P_{t-1,j} - P_{t-1,i}\right)$$

$$b_{ij} = \bar{b} + A_{D,i} + A_{S,j}$$