Genetic Improvement of Socially Affected Traits

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The Issue

The phenotype of an individual may depend on genes in other individuals

Cannibalism in laying hens

Growth in aquaculture

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1. Formulating response to selection

2. Factors determining the accuracy of selection

1. Formulating response to selection

Formulating response to selection

Common expression: $\Delta G = i \rho \sigma_G$

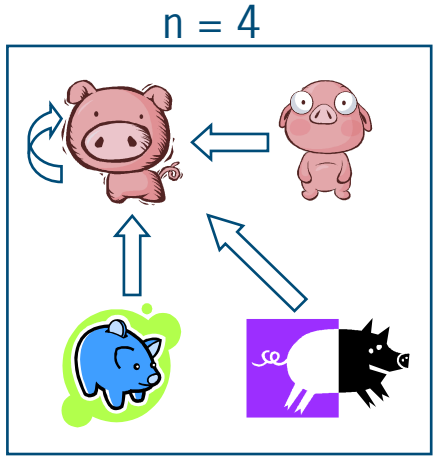
i = selection intensity

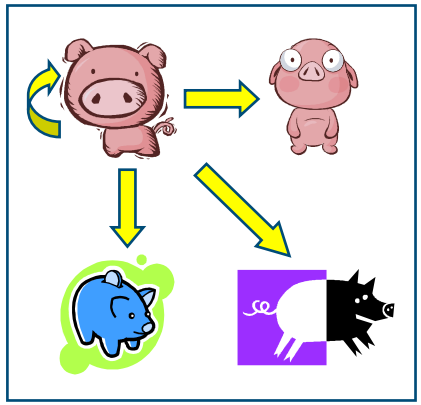
ρ = accuracy of selection

σ_G = genetic standard deviation

Issue: Does this generalize to socially affected traits?

Formulating response to selection





Phenotype: $P_i = \underbrace{A_{D,i} + E_{D,i}}_{\text{Direct effect}} + \underbrace{\sum_{n-1}\left(A_{S,j} + E_{S,j}\right)}_{\text{Social effects}}$

Response: $\bar{P} = \bar{A}_D + 3\bar{A}_S \rightarrow \Delta\bar{G} = \Delta\left[\bar{A}_D + 3\bar{A}_S\right]$

Breeding value: $G_i = A_{D,i} + 3A_{S,i}$

"Genetic" variance: $\sigma^2_G = \sigma^2_{A_D} + 6\sigma_{A_{DS}} + 9\sigma^2_{A_S}$

Accuracy: $\rho = corr(SC_i, G_i)$

Response: $\Delta\bar{G} = i\rho\sigma_G$

Conclusions

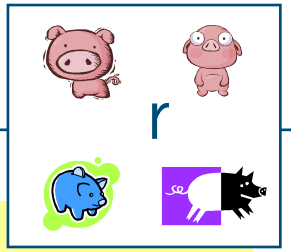
- Social effects fit in the classical framework: $\Delta G = i\,\rho\,\sigma_G$
- This requires that we define breeding value and genetic variance from a "response to selection" perspective
- Breeding value
  - BV = Heritable impact of individual on mean trait value of population
  - BV ≠ Heritable component of own phenotype
- Genetic standard deviation
  - σ_G = Potential response to selection
  - σ_G ≠ Genetic component of Var(P)

2. Factors determining accuracy

$$\Delta\overline{G} = i\rho\sigma_G$$

1. Mass & group selection
2. Selection on sib-info
3. Selection on BLUP-EBV

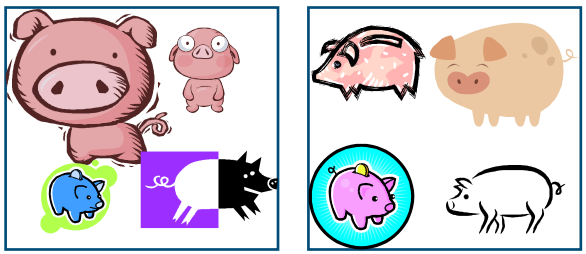
2. Factors determining accuracy

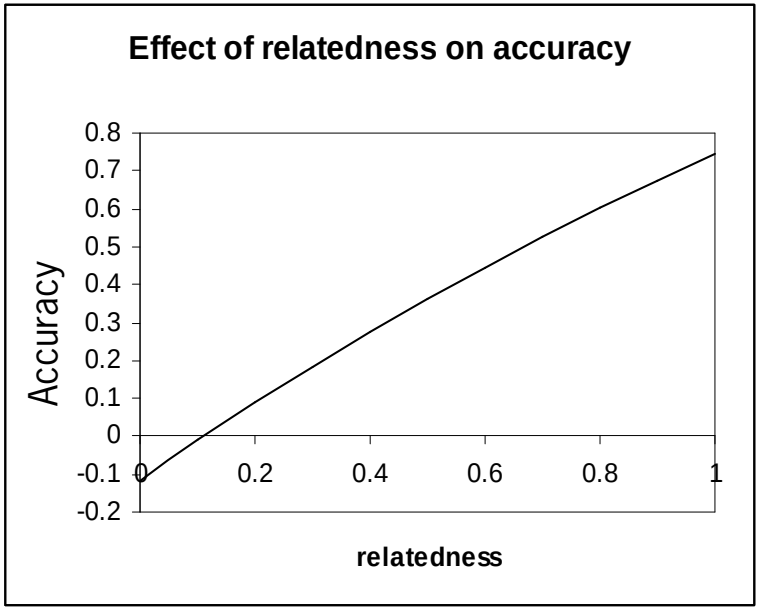


Relatedness among group members is the key driver of accuracy

Mass Selection

Select the best individual



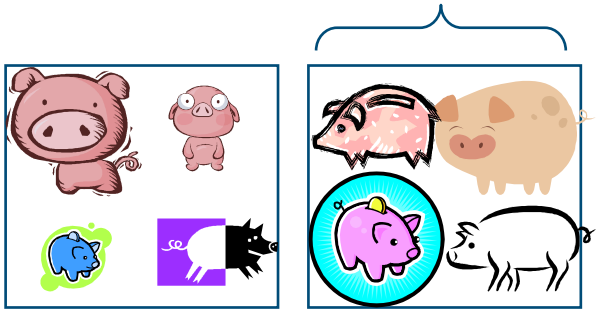


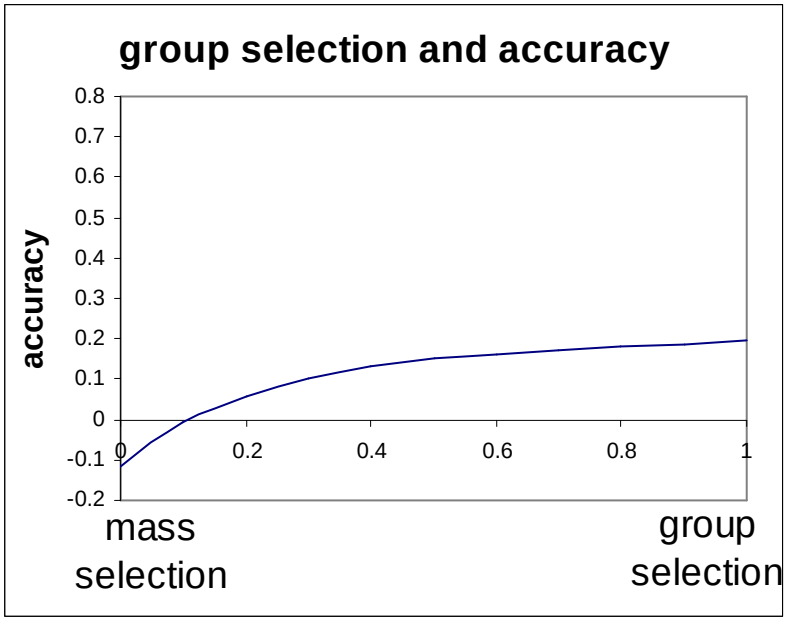
2. Factors determining accuracy

Group selection is less important than relatedness

Group Selection

Select the best group



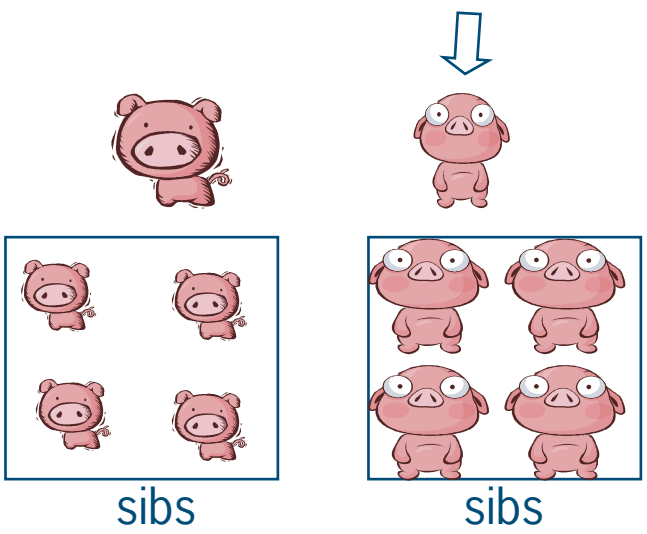


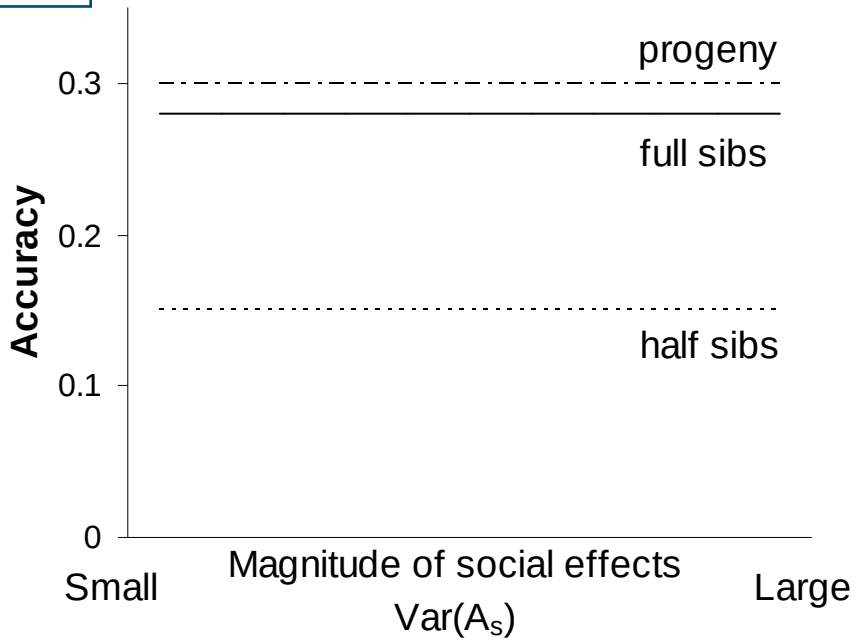
2. Factors determining accuracy

Selection based on sibs kept in family groups is robust

Sib Selection

Select candidate with best sibs





Selection on BLUP-EBV

- You need to know the genetic parameters
- BLUP $\rightarrow$ EBV_D , EBV_S
  - Optimum index: $EBV = EBV_D + (n-1)\, EBV_S$
- Relatedness within groups increases accuracy substantially
- Relatedness is more important than the selection method:
  - "Group selection with FS-groups" better than "BLUP with unrelated groups"
- "Nothing can beat BLUP" when the design is the same

Conclusions

- Social effects fit in the classical framework: $\Delta G = i\,\rho\,\sigma_G$
- Relatedness among interacting individuals is the key driver of accuracy

Formulating response to selection: Example

- Maternal effects:

$$P_{off} = A_{D,off} + A_{M,dam} + e$$

$$\Delta\overline{G} = \Delta\left[A_D + A_M\right]$$

$$\sigma^2_G = \sigma^2_{A_D} + 2\sigma_{A_{DM}} + \sigma^2_{A_M}$$

$$\rho = corr(SC_i, A_{D,i} + A_{M,i})$$

$$\Delta G = i\rho\sigma_G$$

- This extends by analogy (Bouwman *et al.*, in prep.)

2. Factors determining accuracy

Selection based on sibs kept in family groups is robust