Feed-a-Gene

Adapting the feed, the animal and the feeding techniques to improve the efficiency and sustainability of monogastric livestock production systems

Structured antedependence model for longitudinal analysis of social effects on ADG in rabbits

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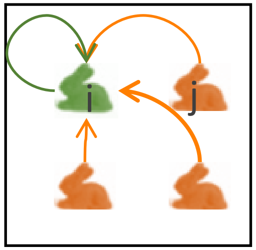
Backgroung

- For animal welfare, group housing is recommended in many species
  - Social genetic effects (SGE) may affect phenotypes of interest

$\text{Phenotype}_i = \text{direct effects}_i + \sum_{j=1}^{3} \text{indirect effects}_j$



- SGEs may vary over time
  - In group housing conditions, aggressive behavior is generally stronger at mixing and tends to decrease with time

- Few genetic studies have investigated the changes of SGE over time for traits under selection in livestock species.

Goal

- Propose an appropriate model to evaluate changes of SGE (and DGE) over time
- Apply this model to study longitudinal ADG in rabbits
- *Evaluate if it is necessary to account for that phenomenon for selection.*

The model

- For animal *i*, in group *m* with co-mate ϵ K_i at time t_j

$$y_{im}(t_j) = \mu_i(t_j) + DGE_i(t_j) + \sum_{k \in K_i} SGE_k(t_j) + g_m(t_j) + \varepsilon_i(t_j)$$

The problem

- For animal *i*, in group *m* with co-mate ϵ K_i at time t_j

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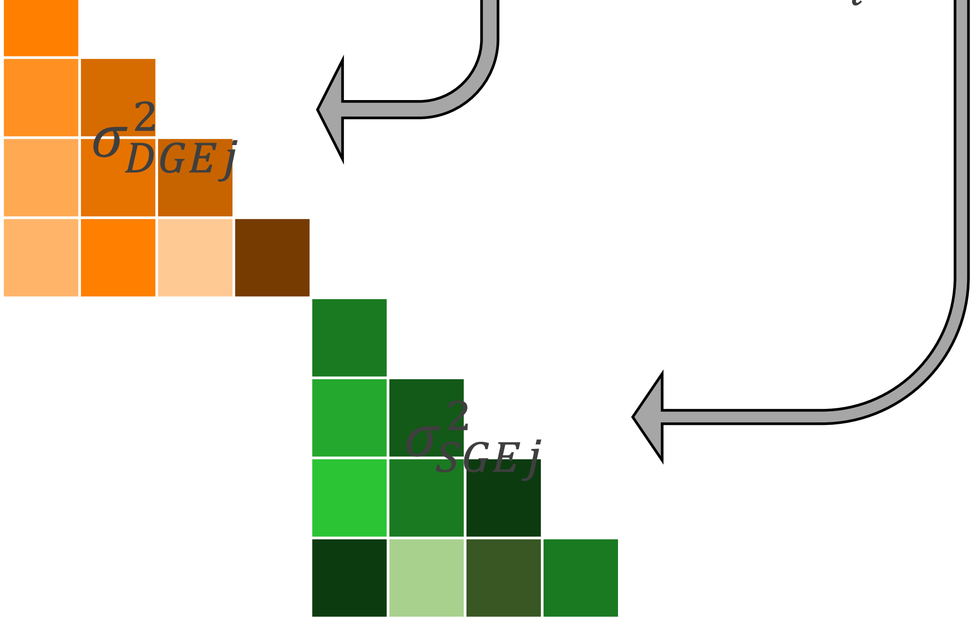

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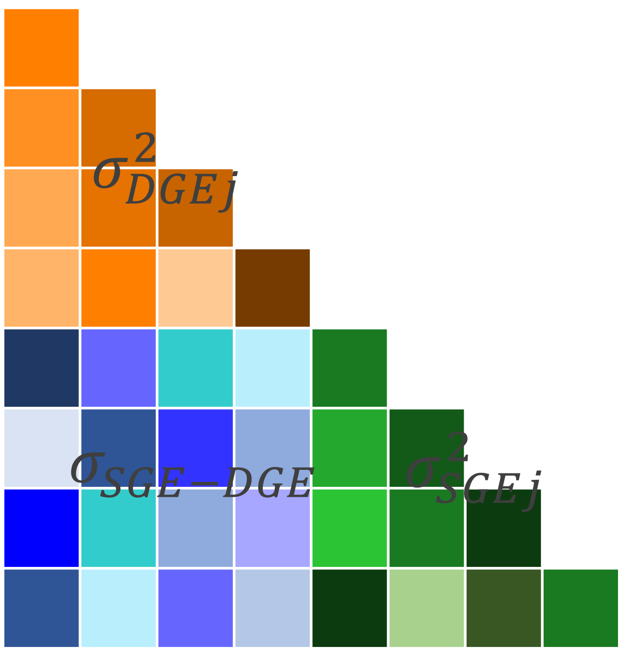


- For n time-points

➔ $\frac{2n(2n+1)}{2}$ genetic parameters

➔ $\frac{n(n+1)}{2}$ parameters other random effects

Large number of parameters

The problem

- For animal *i*, in group *m* with co-mate ϵ K_i at time t_j

$$y_{im}(t_j) = \mu_i(t_j) + DGE_i(t_j) + \sum_{k \in K_i} SGE_k(t_j) + g_m(t_j) + \varepsilon_i(t_j)$$

  - US ➔ too many parameters

  ⬇

  - Character process
  - Random regression

The problem

- For animal *i*, in group *m* with co-mate ϵ K_i at time t_j

$$y_{im}(t_j) = \mu_i(t_j) + DGE_i(t_j) + \sum_{k \in K_i} SGE_k(t_j) + g_m(t_j) + \varepsilon_i(t_j)$$

  - US ➔ too many parameters

  - ~~Character process~~
  - ~~Random regression~~
  - Structured antedependence model

Structured antedependence model

- model an observation at time t by regression on the preceding observations.

$$\theta_{s,j} = a_s + b_s t_j + \cdots$$

$$g_i(t_j) = \sum_{s=1}^{\alpha} \theta_{s,j} g_i(t_{j-s}) + e_{g,i}(t_j)$$

$$e_{g,i}(w_j) \sim N(0, {\sigma_j}^2)$$

$${\sigma_j}^2 = \exp(a + bt_j + \cdots)$$

  - OWN fortran program for ASReml
  - Selection order antedependence and degree polynomial function using LRT

Structured antedependence model

- model an observation at time t by regression on the preceding observations.

$$\theta_{s,j} = a_s + b_s t + \cdots$$

$$g_i(w_j) = \sum_{s=1}^{\alpha} \theta_{s,j} g_i(w_{j-s}) + e_{g,i}(w_j)$$

$$e_{g,i}(w_j) \sim N(0, \sigma_j{}^2)$$

$$\sigma_j{}^2 = \exp(a + bt + \cdots)$$

$$SGE_i(w_j) = \sum_{s=1}^{\alpha\prime} \theta'_{sj} SGE_i(w_{j-s}) + e_{SGE,i}(w_j)$$

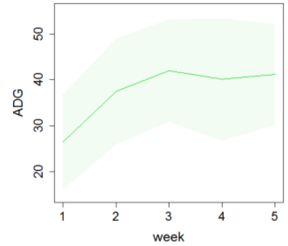
$$DGE_i(w_j) = \sum_{s=1}^{\alpha} \theta_{sj} DGE_i(w_{j-s}) + \delta_j SGE_i(w_j) + e_{DGE,i}(w_j)$$

- extension of the SAD approach to the correlated-effects case is straightforward

Evaluate changes of SGE (and DGE) over time for ADG in rabbit

Data application

- IRTA experiment
  - 3,096  , pen of 8, restricted feeding (75%)
  - weighed at weekly intervals over a 5-week period
  - 5 ADG/ animal



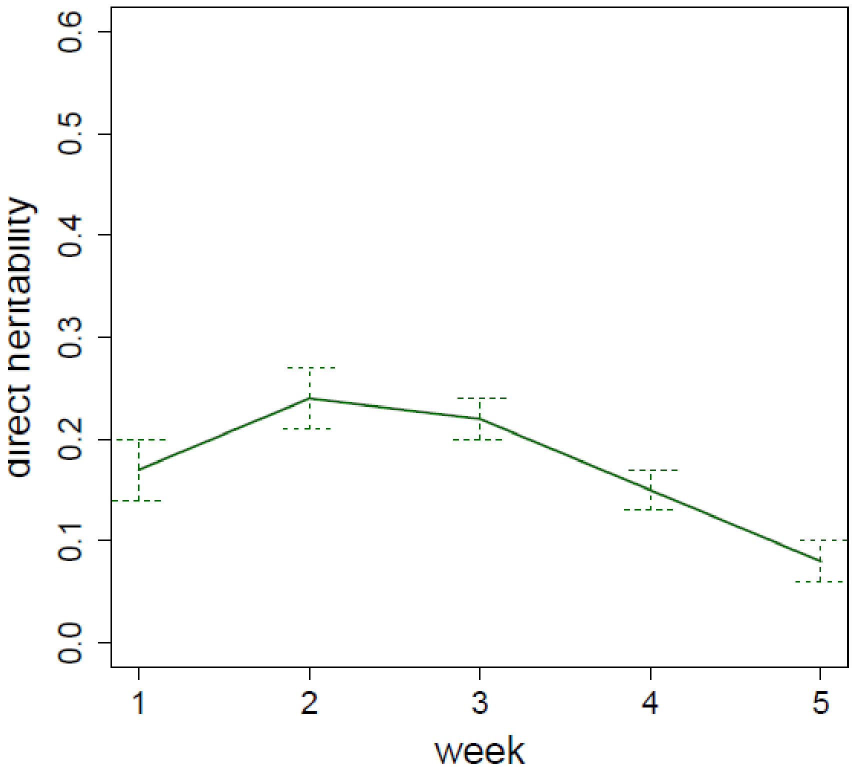
$$ADG_{ilm}(t_j) = \mu_i(t_j) + DGE_i(t_j) + \sum_{k \in K_i} SGE_k(t_j) + g_m(t_j) + l_l(t_j) + \varepsilon_i(t_j)$$

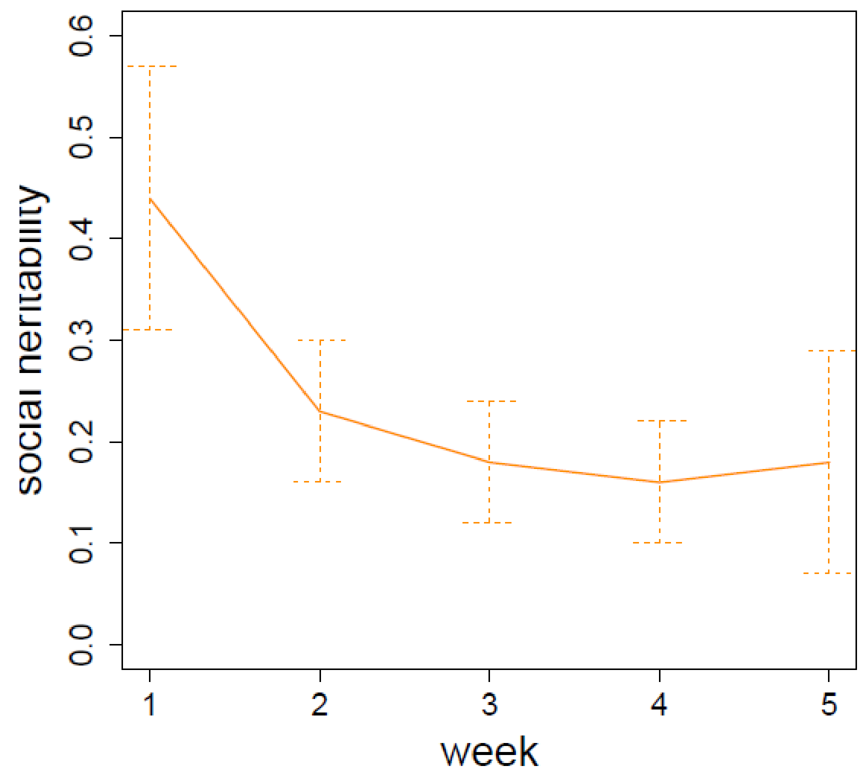
- SAD: 22 parameters instead of 100

Evaluate changes of SGE (and DGE) over time for ADG in rabbit

Result

- heritabilities

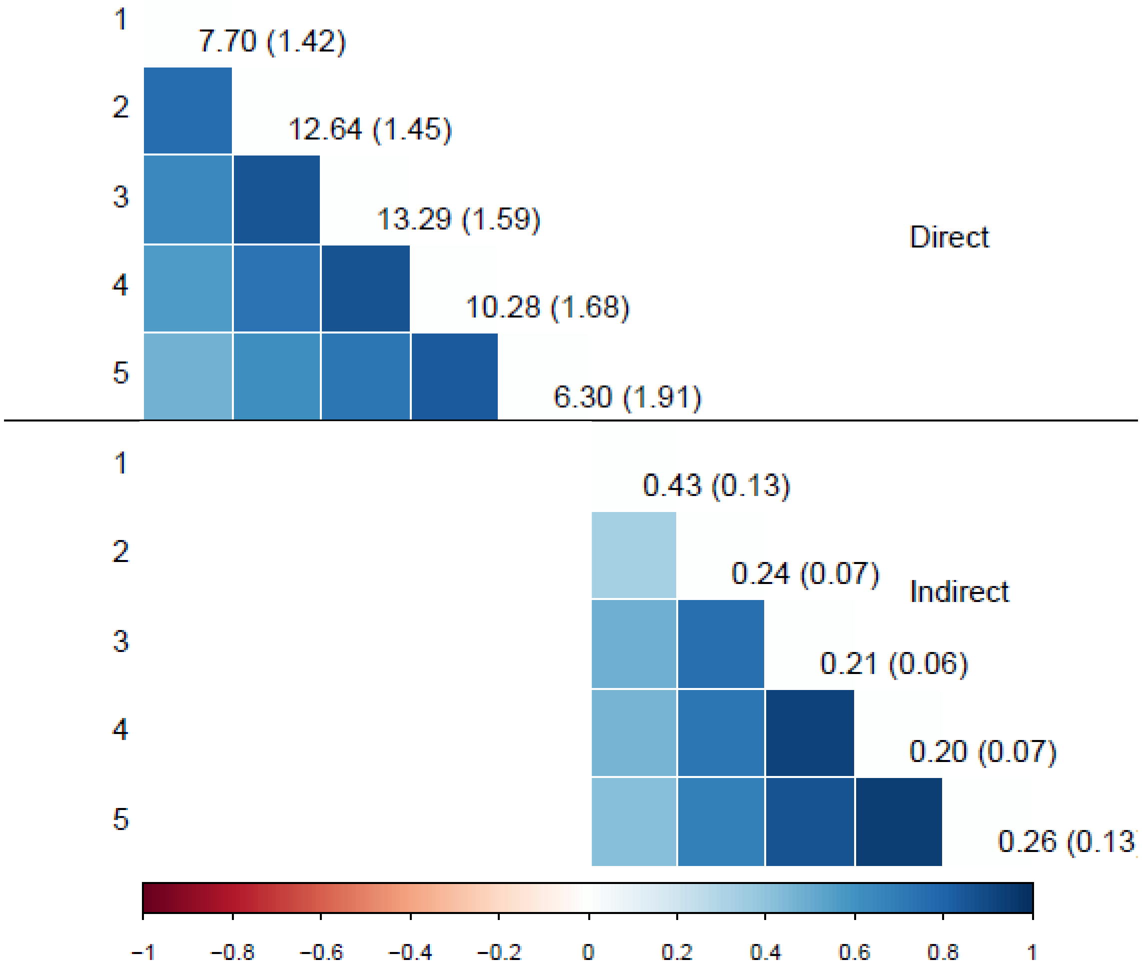




First week : higher social h^2

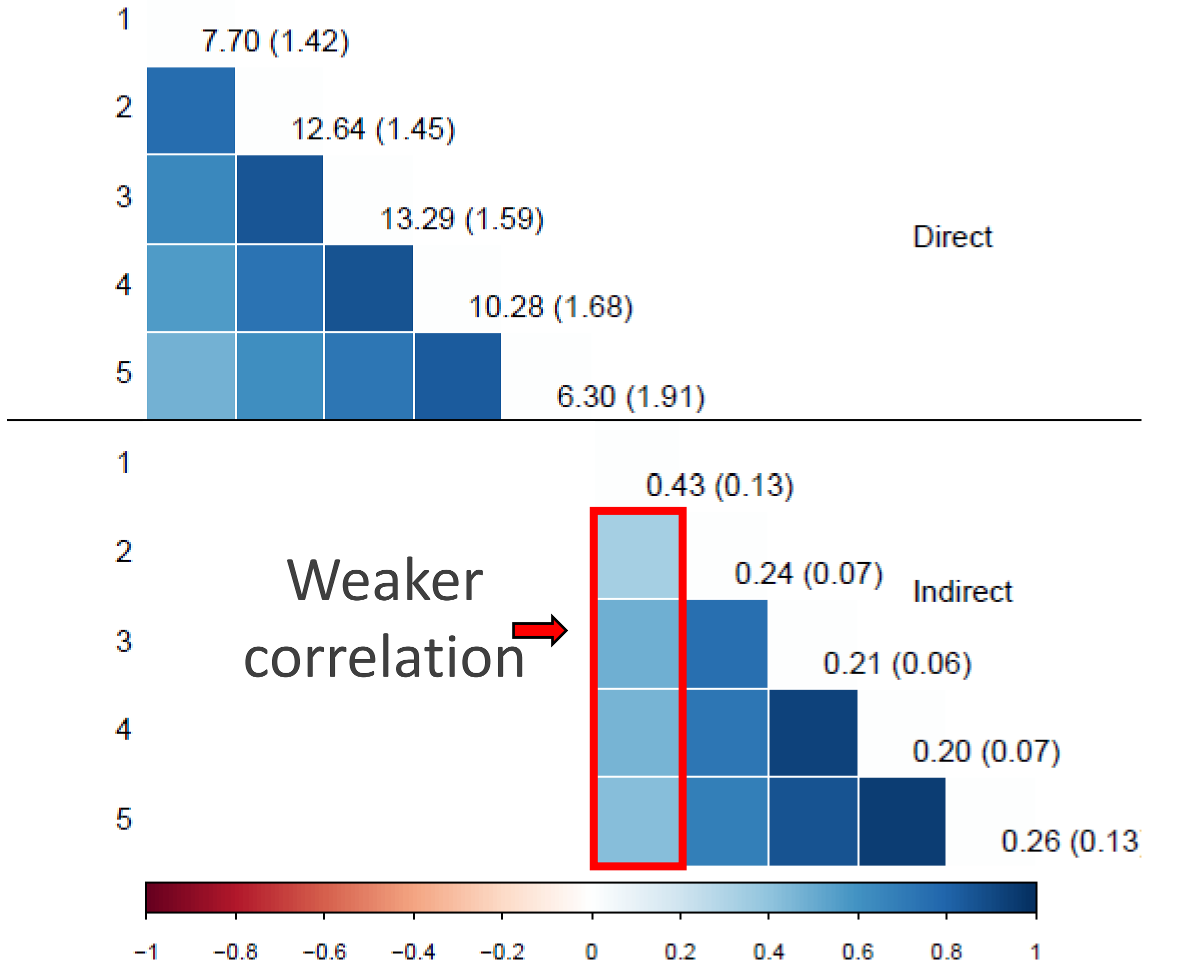
Evaluate changes of SGE (and DGE) over time for ADG in rabbit

Result ◗ Genetic correlations



Evaluate changes of SGE (and DGE) over time for ADG in rabbit

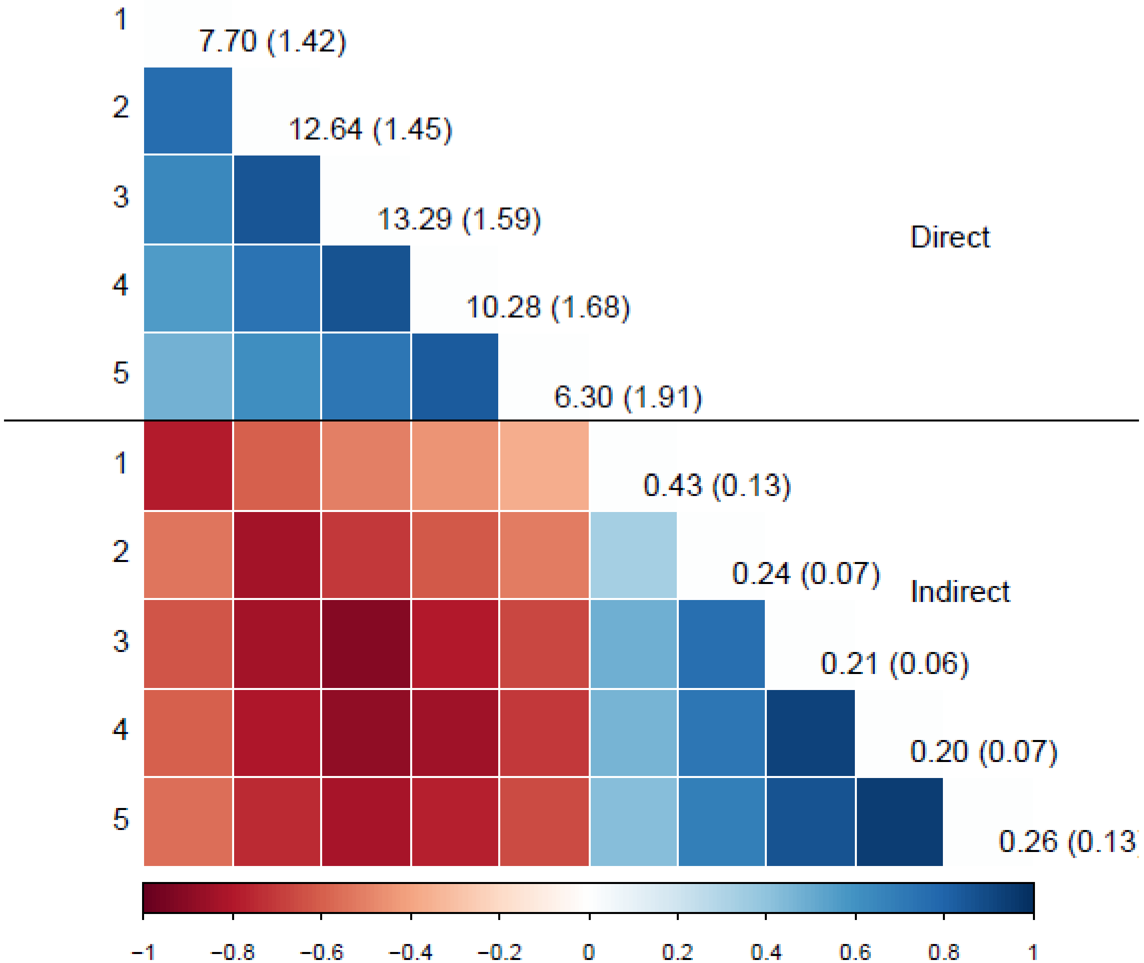
Result ◗ Genetic correlations



SGE first week = different trait

Evaluate changes of SGE (and DGE) over time for ADG in rabbit

Result ◗ Genetic correlations



Genetic antagonism between direct and social genetic effects

Evaluate changes of SGE (and DGE) over time for ADG in rabbits

In summary

- Genetic variances vary over time
- SGE first week is a different trait than SGE of the following weeks
- There is a genetic antagonism between direct and social genetic effects

General conclusion

- This study confirms the hypothesis of changes of SGE over time
- SAD model was appropriate to model these changes
  - SAD programs for correlated random effects are freely available on zenodo https://zenodo.org/record/1228058

account for ΔSGE for selection.

Method

- Simulation study
  - Same design as the experiment
  - SGE, DGE simulated using an unstructured covariance matrix
  - 7 generations of selection
    - Criterion 1: EBV* from a SAD model without SGE
    - Criterion 2: TBV* of the first week (SAD model)
    - Criterion 3: sum of the weekly TBV* (SAD model)

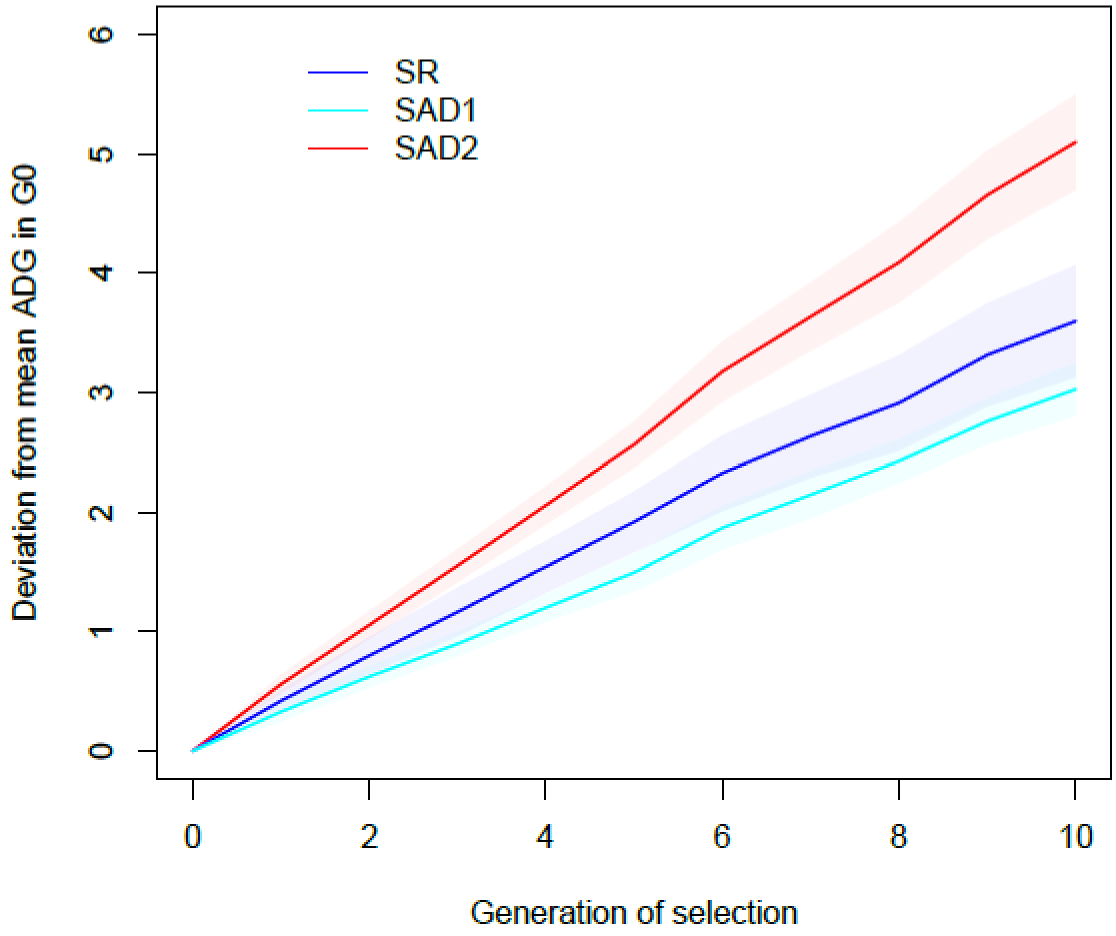
*TBV=EBVd+7*EBVs

↓

Changes in ADG over generations

account for ΔIGE for selection.

Result



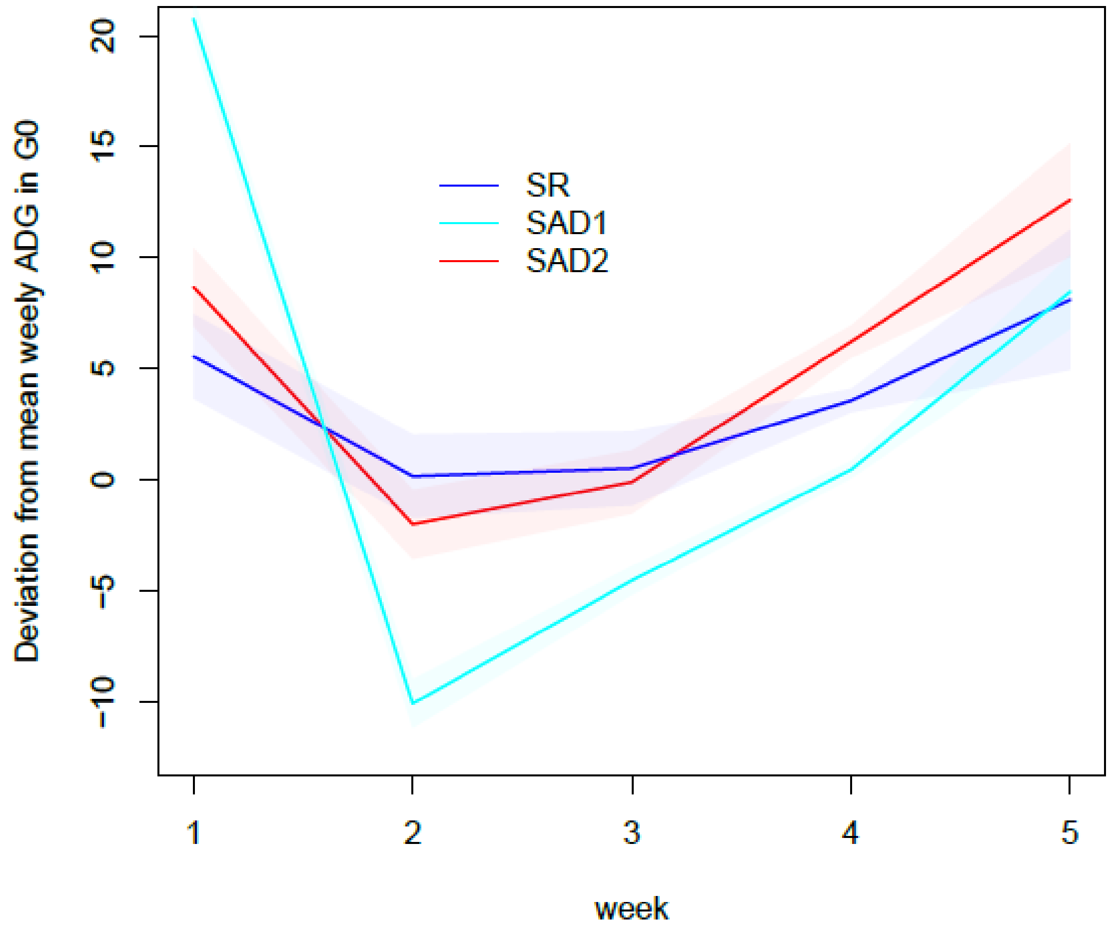
account for ΔIGE for selection.

Conclusion

- Selection is more efficient when changes of SGE over time are taken into account

account for ΔIGE for selection.

Result



$$\boldsymbol{y}(t)=\mu(t)+\boldsymbol{u}(t)+\boldsymbol{p}(t)$$

$$\boldsymbol{p}(t_0)=\boldsymbol{e}(t_0)$$

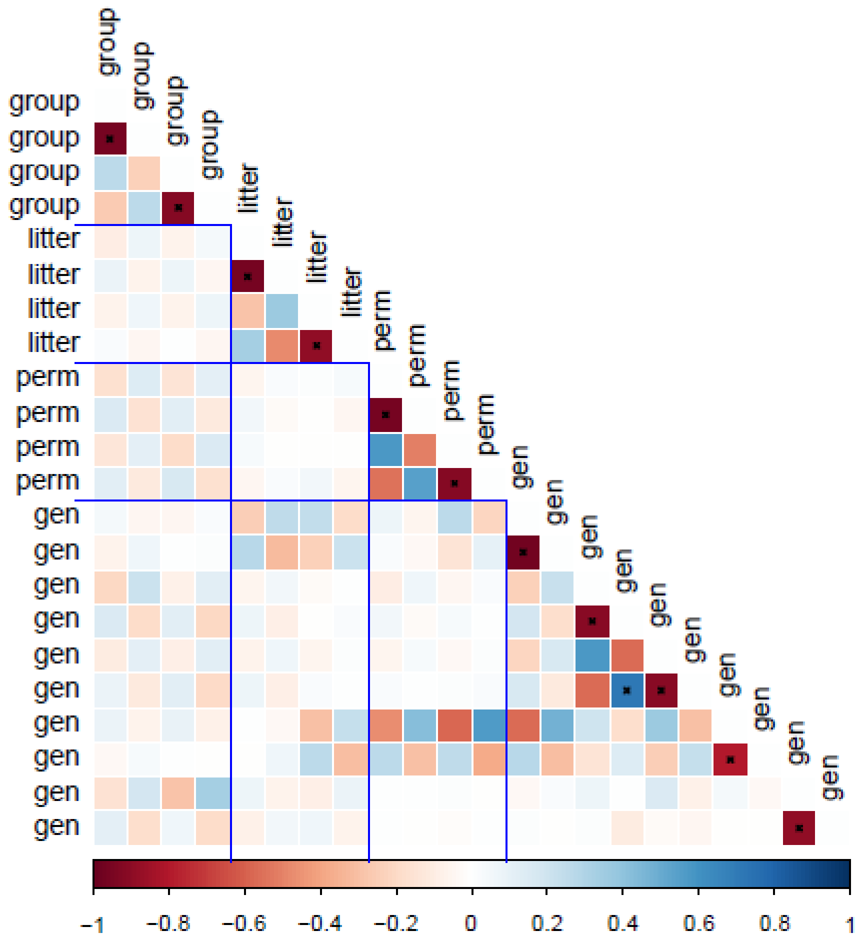
$$\boldsymbol{p}(t_j)=\sum_{k=1}^{s}\boldsymbol{\theta}_{kj}\boldsymbol{p}(t_{j-k})+\boldsymbol{e}(t_j)$$

$$\boldsymbol{e}(t_j)\sim N(0,\sigma_{ej}^2),\sigma_{ej}^2=\exp(a+bt+ct^2+\ldots)$$

$$\boldsymbol{\theta}_{jk}=a'+b't+\ldots$$

SAD ordre-degré dep, degré variance Ex: SAD 1-00, SAD2-101

Identifiability
Correlation matrix between parameters estimates



Identifiability

Correlation matrix between variance component estimates