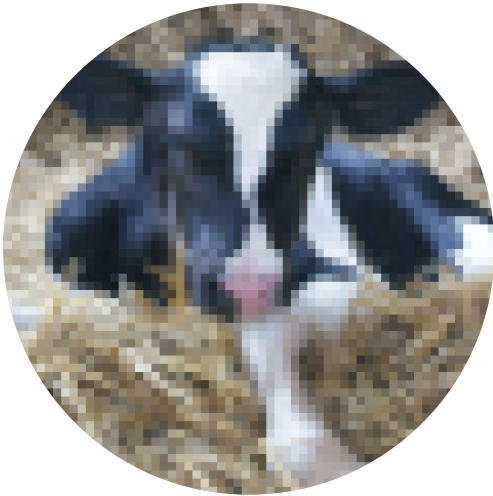


Digital twins of breeding programs

Predicting the agility of breeding programs to adapt to future societal demands

EAAP 2024 - M. P. L. Calus, T. Pook, E. Hanenberg, B. C. Perez, C. Orrett, J. ten Napel



Breeding animals in a fast-changing world

- Societal demands and evolving policies shape the way we keep animals in livestock production
 - Farming systems for better health & welfare and lower environmental burden
- Impact on animal breeding
 - Changes in desired animal characteristics
 - Changes in target living environment



Agility of animal breeding

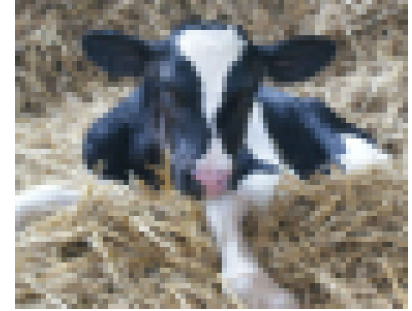
- *Contradictio in terminis?*
- Animal breeding programs have a long response time
 - Long generation intervals
 - Small changes per generation, so multiple generations needed
- Need to know accurately and swiftly what needs to be done!

Current practice of modelling breeding program

- Deterministic tools: MTINDEX, SelAction, selind, ZPLAN
 - Simplified version of actual breeding program
 - Assuming perfect implementation & full control
 - Focus is on the overall genetic design of the breeding program
- Stochastic tools: QMSim, Adam, AlphaSimR, MoBPS
 - Design of the breeding program in more detail
- Negative impact on agility of breeding program

Digital twin of a breeding program

- Up-to-date digital copy of actual breeding program
 - Includes known history
- Operational at any time
 - To consider changes in structure of breeding program
 - To evaluate a different selection environment
 - To anticipate a changing breeding goal for future production environments
- Outcome tailored to actual situation



MoBPS – versatile modelling package

- R-based package
- Written to model actual breeding programs
- Allows to mimic actual breeding value estimation & genetic selection
 - Support for MiXBLUP & BLUPF90
- Supports inclusion of breeding program history
- Our choice of software to build digital twins!

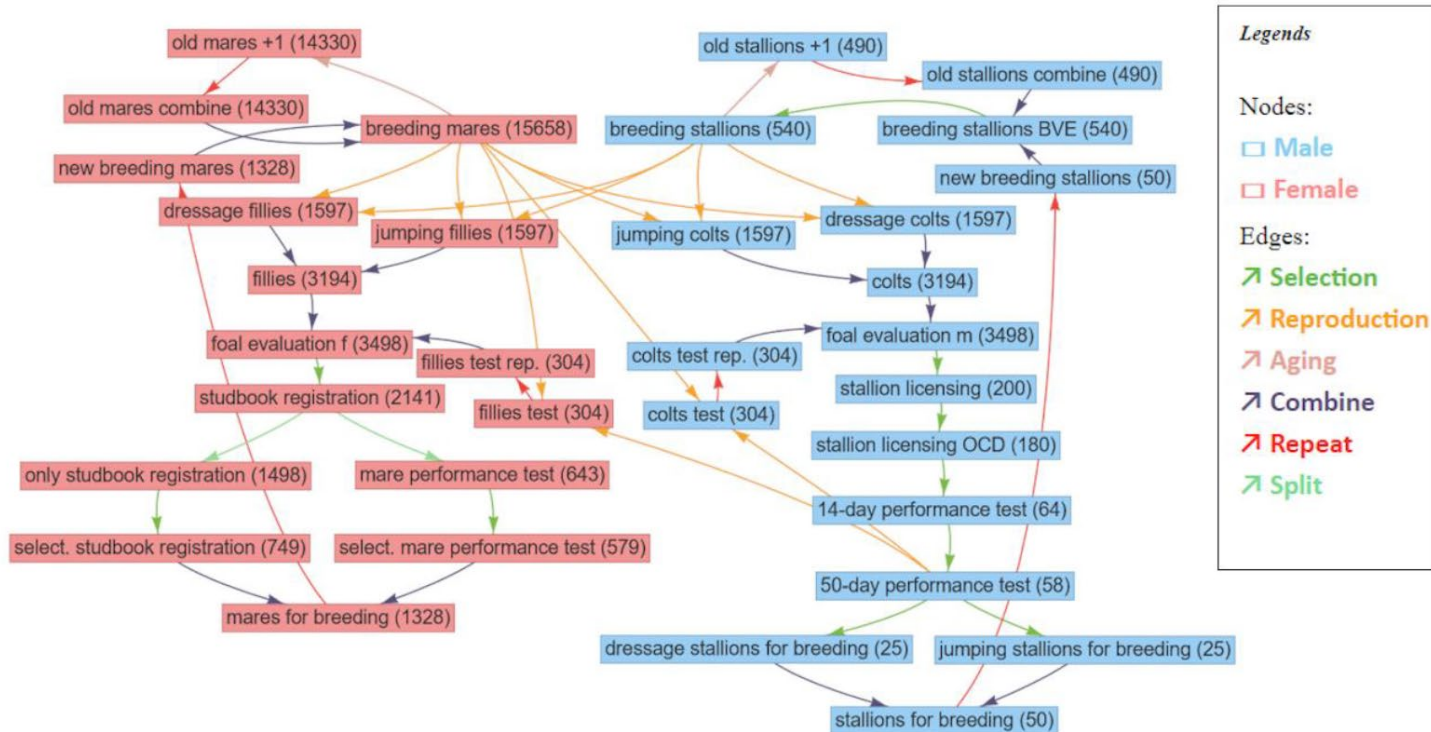


Example 1 – osteochondrosis in horse breeding*

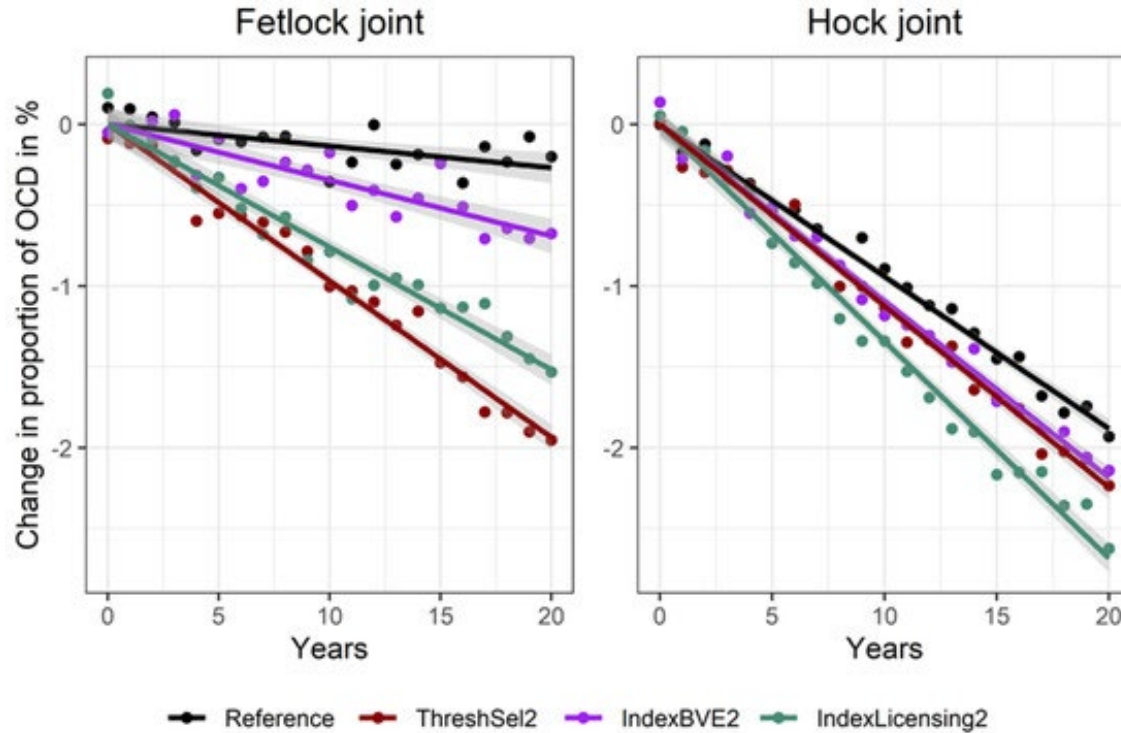
- Osteochondrosis dissecans (OCD) is a health issue in horses with a genetic background
- Aim: what are adequate breeding strategies to reduce OCD prevalence?
- Use MoBPS to mimic real-life riding horse breeding program
 - Number of different selection steps
 - Realistic age structure
 - Performance and health traits

* Büttgen *et al.* (2020); Animals 10: 1153

Illustration of simulated breeding programme



Example 1 – osteochondrosis in horse breeding



OCD in hock joint improves as a correlated response

IndexLicensing2 has the highest overall gain

Example 2 – calving ease beef cattle

- Majority of cows of double-muscled beef cattle breed give birth by caesarean section
- Selection for muscling favoured both double-muscling allele and reduced wither height
 - A smaller internal pelvic height & width as correlated response
 - An increase of dystocia as a consequence
- Societal pressure to reverse dystocia



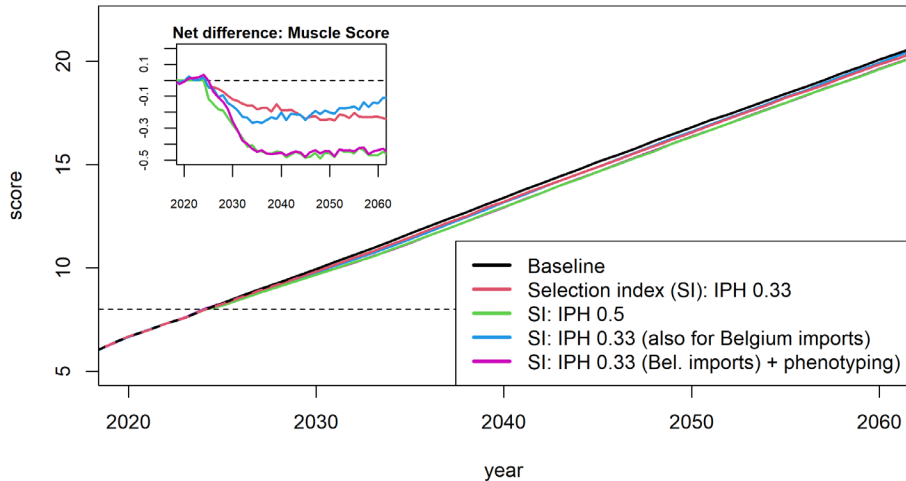
Example 2 – calving ease

■ Breeding program modelled

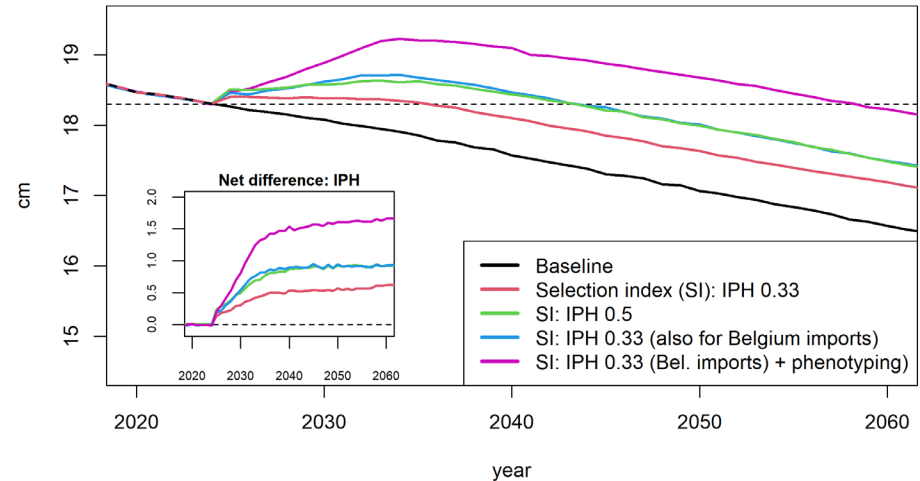
- 200 young bulls per year from Belgium; 50 from the Netherlands
- Pelvic measurement program at 25% of Dutch breeders
- Breeding values for muscling available before first use of bulls
- Breeding values of internal pelvic measurements only 30 months after first use by breeders involved in pelvic measurement program
- Selection index of muscling and internal pelvic height

Example 2 - Response of selection

Muscle Score



Internal pelvic height



Summary

- A digital twin can improve the agility of a real-life breeding program as it allows for a fast and accurate exploration of future scenarios
- Realistic digital twins of breeding programmes are operational (see next presentation by Laura Vargovic)

Acknowledgements



Workshop: Simulation of breeding programs with the Modular Breeding Program Simulator (MoBPS)

- October 24 & 25
- Fully remotely / online
- Time: 9 to 17 (CEST, Central European Summer Time)

