GEroNIMO and RUMIGEN Joint Final Event

Simulating scenarios of gene editing in dual-purpose chicken breeding programs

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Background: The problem of chick culling

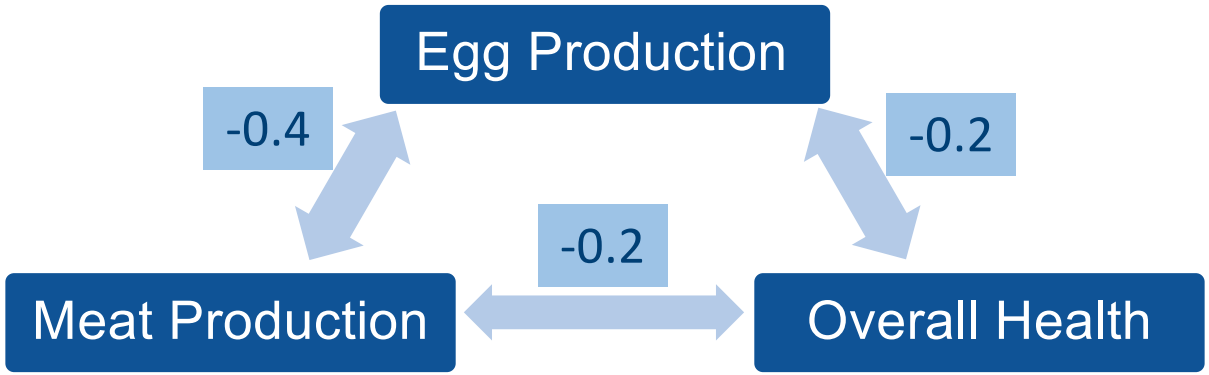
- **The practice of chick culling has raised attention and public concerns**
  - The young male chicks from the laying hens were killed
  - Animal welfare problem
  - Germany and France banned this practice since 2022, other EU countries might follow
- Using **dual-purpose chicken** might be a solution?
  - The male chicks could be used in meat production

Background: Negative genetic correlation

- The dual-purpose chicken are not satisfying in either production performances
- Possible reason: observed **negative genetic correlation** between **egg** production and **meat** production traits
- Gene editing could be used in breeding programs for dual-purpose chicken?
  - This simulation study explore the possibility and potential
  - Many of the assumptions are optimistic, but to explore what could be useful in the future

Simplified simulation of traits

- Three traits: Two performance traits and one health trait are simulated
  - **Egg production, meat production, and overall health**



Index selection

- The simultaneous consideration of all traits by index selection
- **Overall health** is also considered in the dual-purpose selection index
  - **Negative effect of gene editing on overall health** due to off-target effects (5% risk)

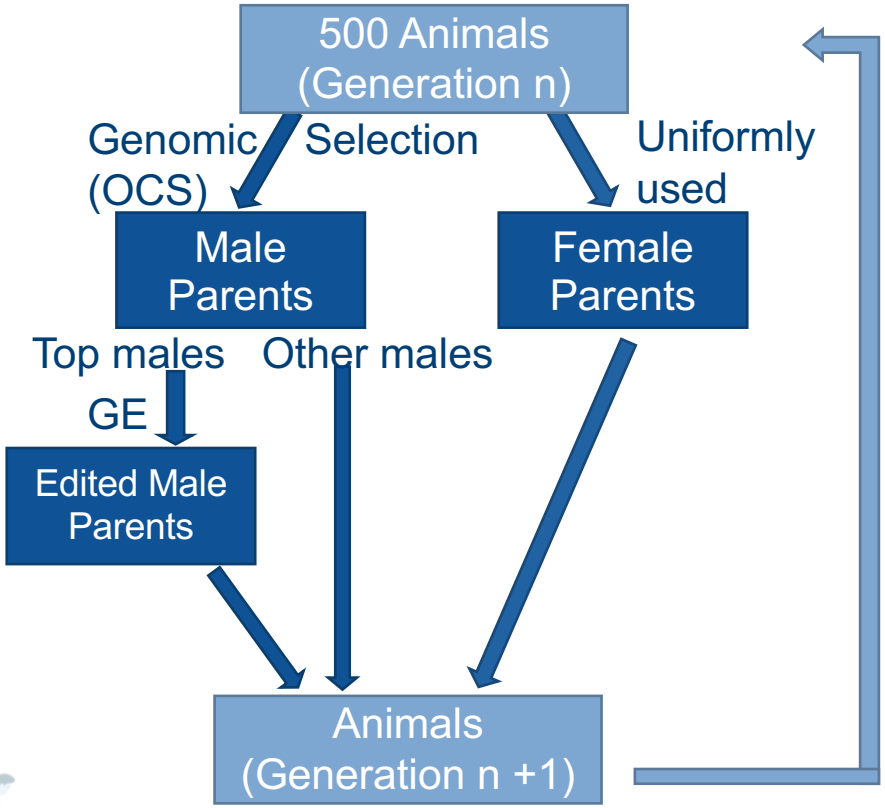
Trait	Egg production	Meat production	Overall health
Index weight of Simulation	37.5 %	37.5 %	25 %

Simulation of gene editing

Assuming the same animal could undergo

- Breeding value estimation
- **Gene editing**
- Reproduction

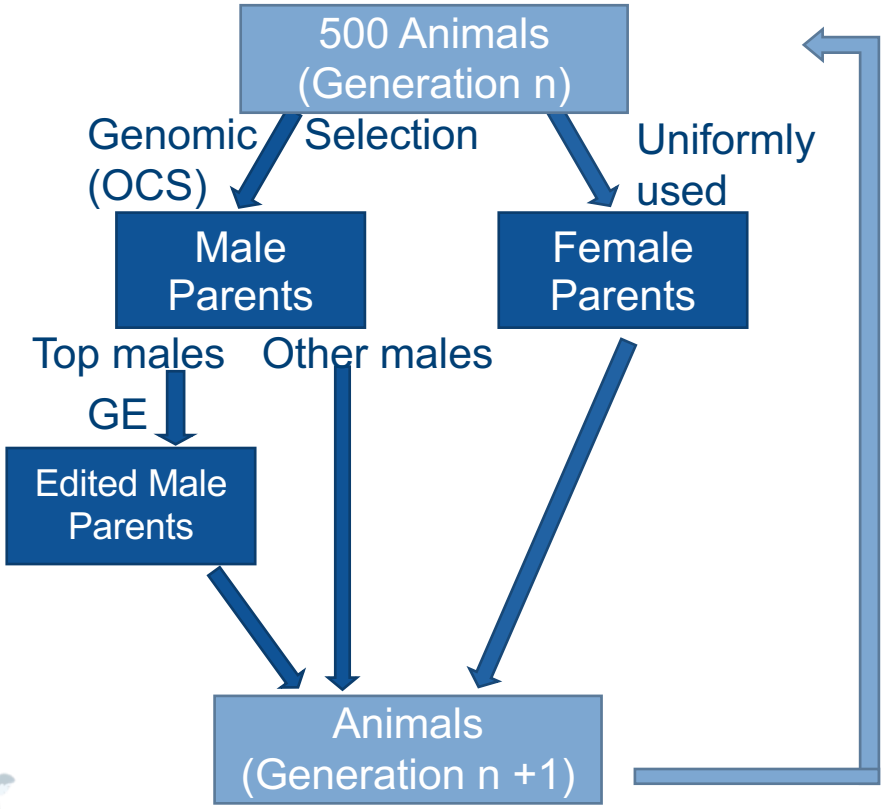
in the **same generation**



OCS = optimal contribution selection

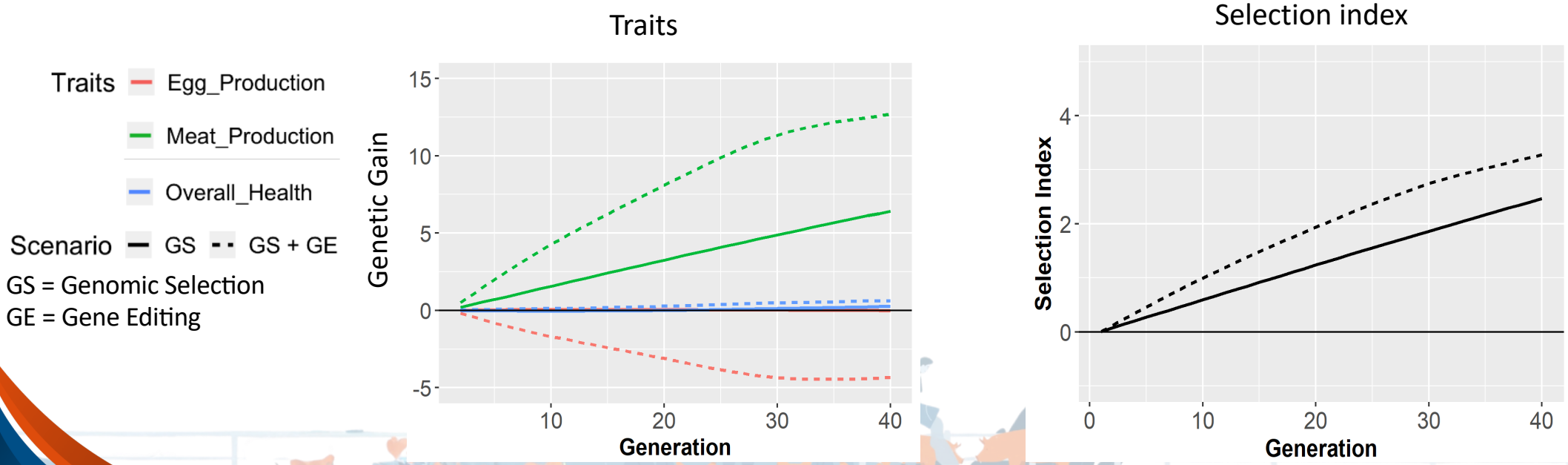
Simulation of gene editing 1 – Editing Many Genes

- Edit the best 25 male animals/ gen.
- For each edit per animal
  - **25** SNPs are edited
  - SNPs with **(estimated) best effects**
  - SNPs not in the beneficial phase
  - Allele count + 1



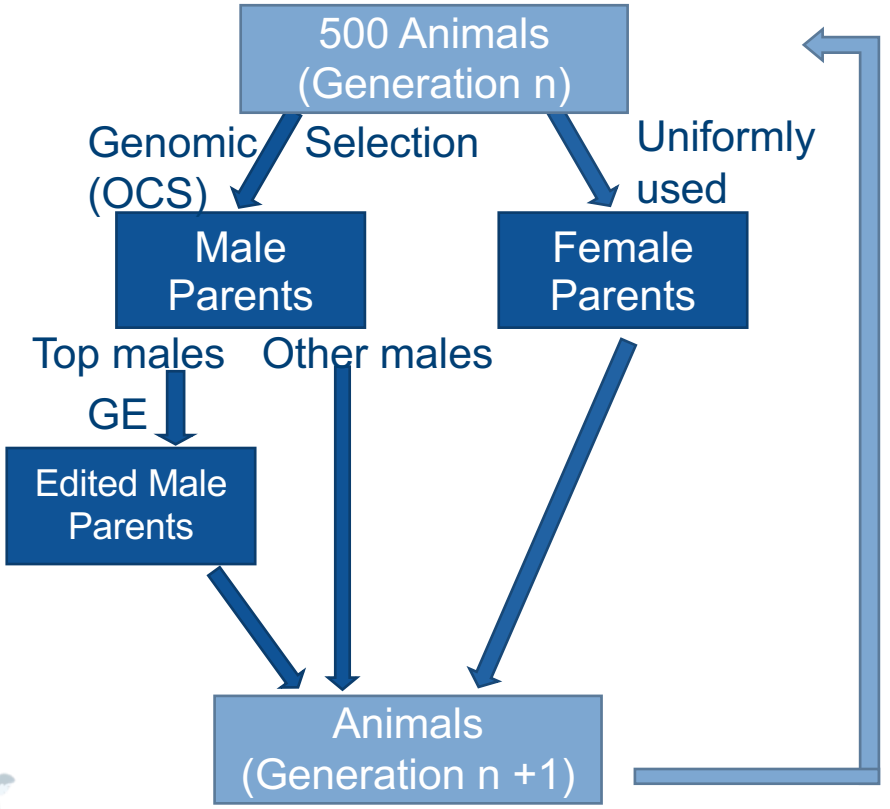
OCS = optimal contribution selection

- Gene editing **sacrifice egg production to improve meat production** in the layer lines
- When evaluated by the selection index, more genetic gain from gene editing



Simulation of gene editing 2 – One major gene

- Simulate one extra QTL
- Only edit the extra QTLs
- Apply gene editing for only **five generations**
- Edit the best 10 males from each generation

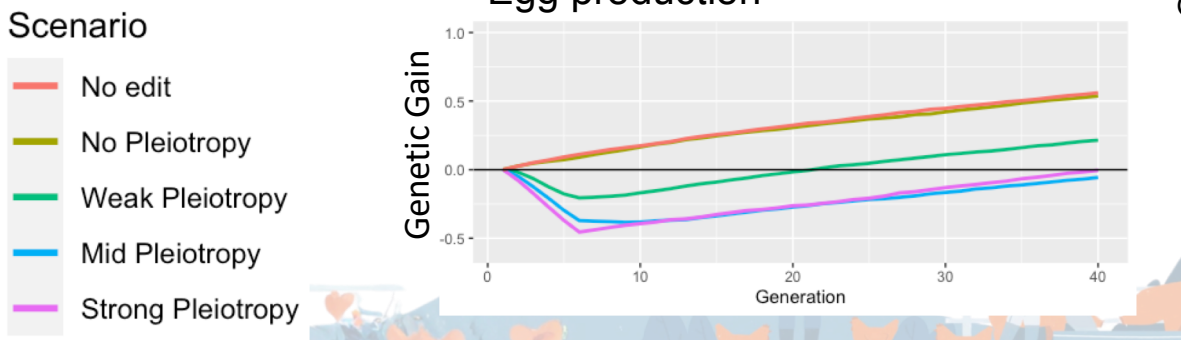


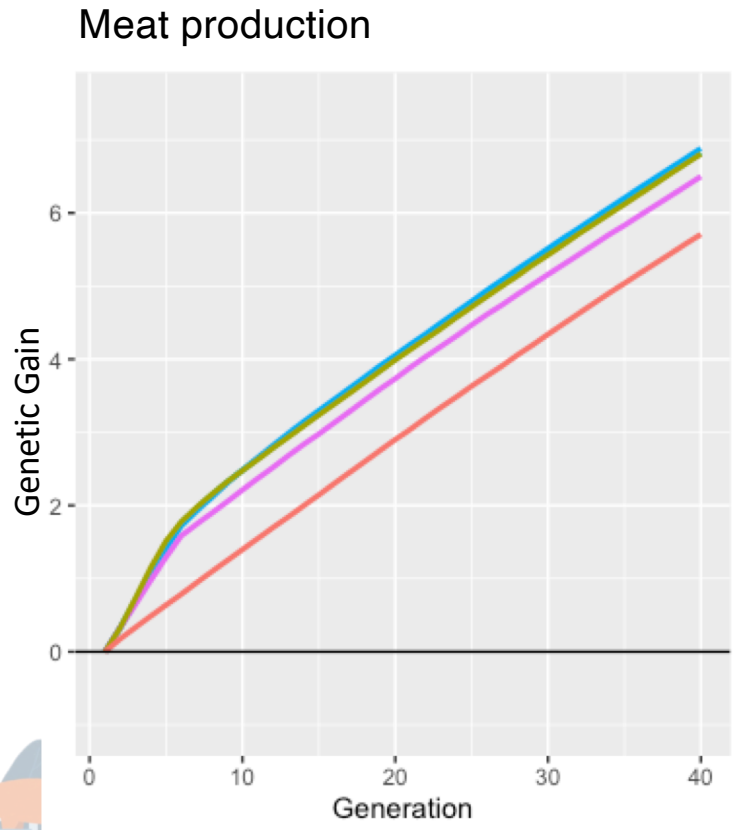
Simulation of gene editing 2 – Pleiotropy

- Assuming the editable novel genes could **improve meat production**
- Four levels of pleiotropy:
  - **No pleiotropy**
  - **Weak pleiotropy** Meat : Egg : Health = 1: - 0.3: - 0.1
  - **Medium pleiotropy** Meat : Egg : Health = 1: - 0.5: - 0.2
  - **Strong pleiotropy** Meat : Egg : Health = 1: - 0.7: - 0.3

Simulation of gene editing 2 –

- Gene editing **increased meat production**
- When pleiotropy exists, gene editing decreased egg production to increased meat production
- When editing strongly pleiotropic genes, the **progress of meat production slows down after editing is stopped**





Final messages

- Potential to implement gene editing in dual-purpose chicken breeding programs was shown but **under optimistic assumption**
- **Meat production** could be improved in **laying hens** by gene editing
- **Pleiotropy** should be considered when introducing novel gene with gene editing
- Future studies are still needed in:
  - Precision identification of causal variables
  - Genetic mechanisms and negative consequences
  - Also other socio-ethical concerns…

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Breeding the Future

Genomics, Epigenomics & Societal Acceptability for Sustainability in Livestock

THANK YOU

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