Prediction of Breeding Values and Aggregate Genotype

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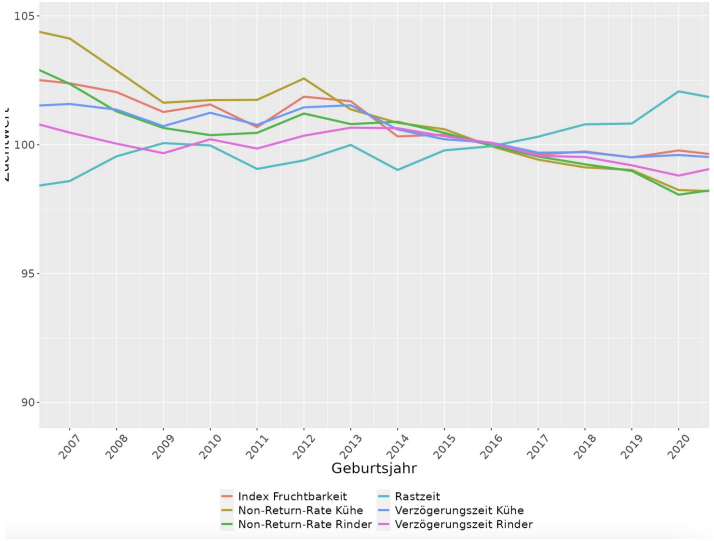
2024-05-15

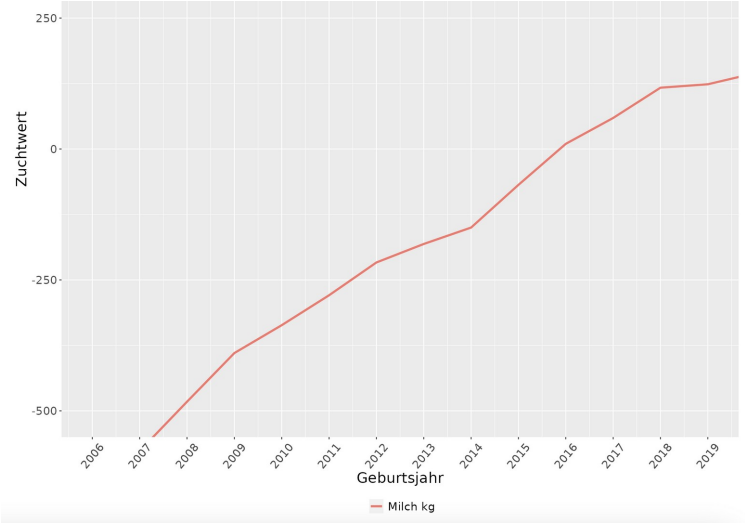
Summary for One Trait

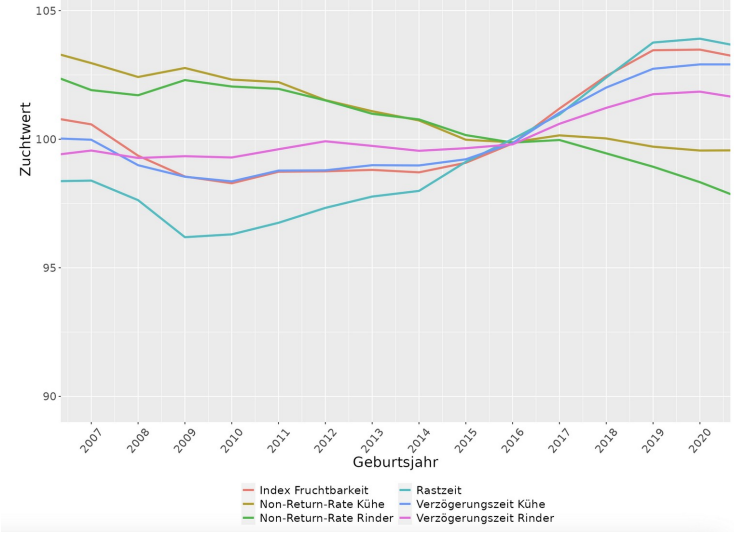
- Predicted breeding values with or without genomic information
- Animals can be ranked according to predicted breeding values
- Problems:
  - Not only one trait should be improved
  - Selection for one trait changes also other traits via correlated selection response

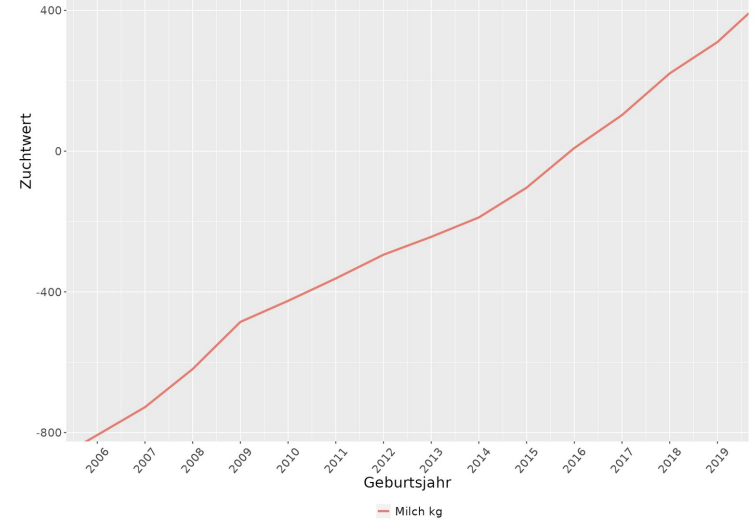
$\rightarrow$ see genetic trends at: https://1-htz.quagzws.com/shiny/users/zws/genTrendHO/DE/2024/

Example Fertility and Production

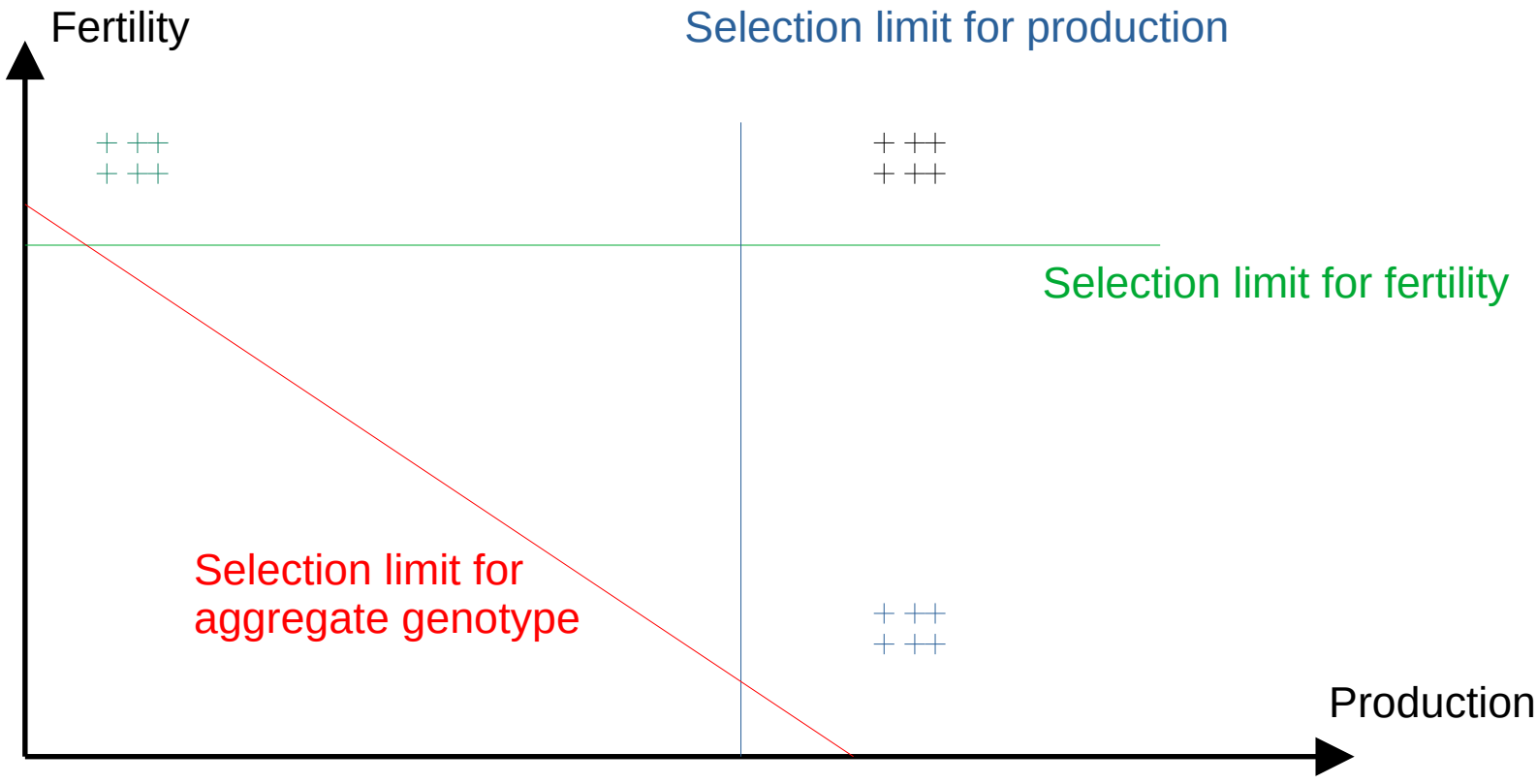








Multi-Trait Selection



Types of Multi-Trait Selection

- Tandem selection
  - select for one trait at the time
  - after goal has been reached change to different trait
- Independent selection limits
  - select only animals which fullfill criteria in all traits
- Selection according to aggregate genotype
  - combine traits into aggregate genotype H
  - define H as weighted sum of true breeding values and economic values
  - use selection index I to estimate H

Aggregate Genotype

Definition in vector notation: $H = v^T \cdot u$

where

- u: vector of true breeding values
- v vector of economic values which are marginal changes in profit for a small change in the population mean of the trait

Estimate H via index I, hence $\hat{H} = I = b^T x$

with

- x: a vector of information sources
- b: a vector of unknown weights.

Determine b such that $var(I - H)$ is minimal.

Find b ...

... such that $var(I - H)$

$$
\begin{aligned}
var(I - H) &= var(I) - 2 * cov(I, H) + var(H) \\
&= var(b^T x) - 2 * cov(b^T x, v^T u) + var(v^T u) \\
&= b^T var(x) b - 2 * b^T cov(x, u^T) v + v^T var(u) v \\
&= b^T P b - 2 * b^T C v + v^T G v
\end{aligned}
$$

Setting $\frac{\partial \ var(I-H)}{\partial b} = 0$ leads to

$$Pb = Cv$$

Hence

$$b = P^{-1} C v$$

Special Case

- Same traits in H and in I
- Use predicted breeding values $\hat{u}$ from multivariate BLUP animal model as information source x
- Then it follows

$$b = P^{-1}Cv = var(\hat{u})^{-1} \cdot cov(\hat{u}, u^T) \cdot v = v$$

Method Works . . .

Studies like

- Berry, D. P., Kearney, J. F., Twomey, K., & Evans, R. D. (2012). Genetics of reproductive performance in seasonal calving dairy cattle production systems. Irish Journal of Agricultural and Food Research, 52(1), 1–16.