

The background of the slide is a close-up, high-contrast photograph of a horse's eye. The eye is dark and partially closed, with long, dark eyelashes visible. The surrounding skin and fur are dark and textured. The overall lighting is dramatic, highlighting the texture of the horse's coat and the intensity of the eye.

INCLUDING GENETIC GROUPS AS FIXED OR RANDOM EFFECTS  
IN LARGE SCALE SINGLE-STEP GENOMIC PREDICTIONS

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# Agenda

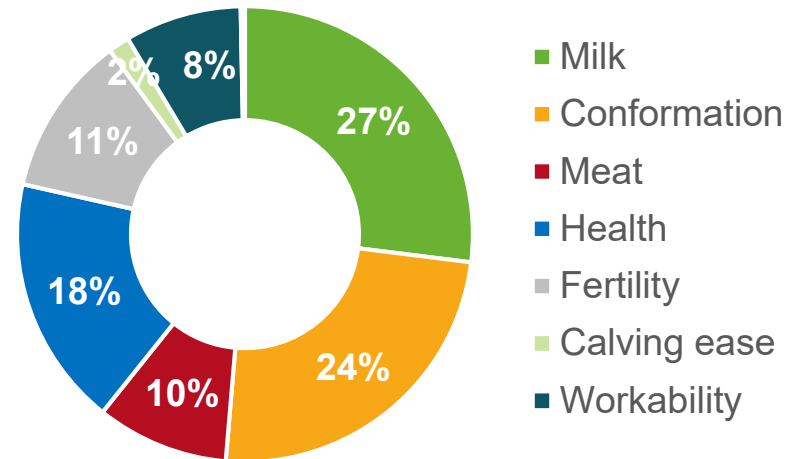
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- Overview of breeding scheme of Norwegian Red
  - Breeding goal
  - Implementation of genomic selection
- ssGBLUP based breeding programme
  - Challenges and biases
  - Solutions
- Genetic groups as random effect reduces some biases

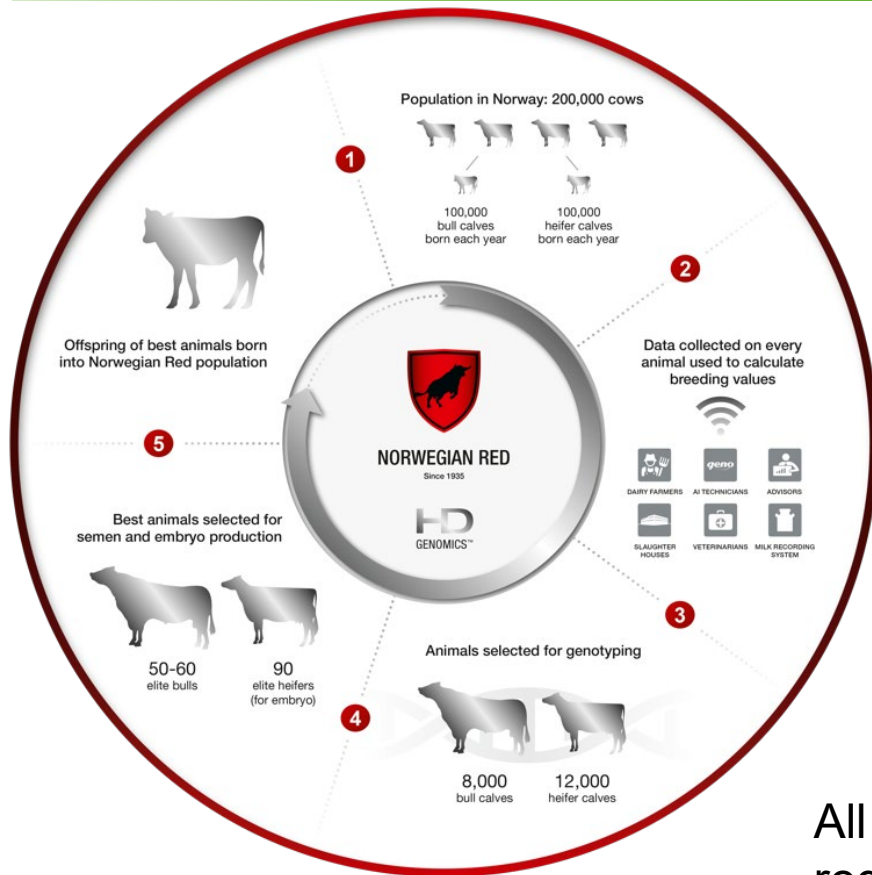
# Norwegian Red

- Breed Established in 1935 by Geno (farmer owned cooperative)
- Dual purpose breed (milk and meat)
- From 70's health and fertility in breeding goal
  - > **40** traits included
- 2012 – genomic selection (SNP-BLUP) of test bulls
- 2015 – ssGBLUP, switched from progeny testing to GS bulls

Relative weight of Group of traits in the Total Merit Index  
**Norwegian Red**



# Norwegian Red – breeding programme



130000 genotypes=>ssGBLUP

30.000 + new genotypes/year

8.000 bull calves

6.000 heifer calves

16.000 + females (producer init.)



All elite bulls and embryo heifers are regentyped on 777K (1823 bulls)

geno



# Challenges with biases

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- Inflation (young genotyped animals overpredicted)
  - Selection of SNPs for the  $H^{-1}$  matrix is crucial
  - Method for building  $H^{-1}$  (setting allele frequencies equal to 0.5)
- Level-bias (Nordbø et al 2019. EBV Increase, after genotyping)
  - Strict filtering of SNPs within and across SNPchips
  - Not adding anything to  $\text{diag}(G)$  before inverting
- Genetic groups
  - Genotyped animals with unknown ancestors are over-predicted
  - Animals with genotyped offspring and unknown ancestors are over-predicted



# 3-trait repeatability animal model for milk

- 3 traits (milk, %protein, %fat) ssGBLUP with genetic groups using QP transformation on  $A^{-1}$  (approximation)
- 124493 genotyped animals
- 8.1 mill. 305d records (1st-5th lactation) on 3.8 mill. animals
- 4.8 mill animals in pedigree, 118 genetic groups
- Mix99

## Gen.corr. and heritabilities

	Milk	Protein%	Fat%
Milk	<b>0.42</b>		
Protein%	-0.44	<b>0.61</b>	
Fat%	-0.36	0.62	<b>0.36</b>

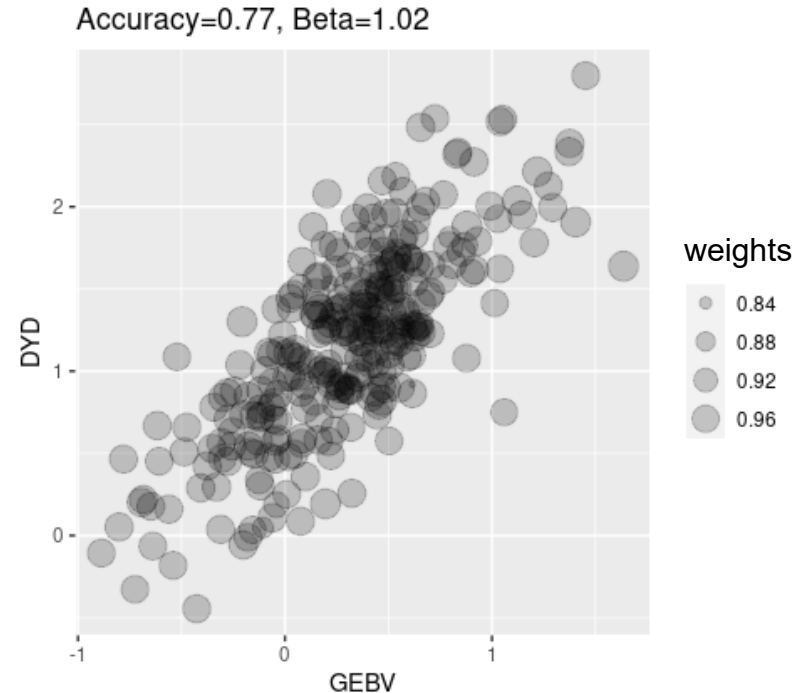
$H^{-1}$  :

- Imputation: to 777k: 122k SNPs
- Allele frequency: 0.5
- Scaling:  $G=ZZ'/k \rightarrow \text{mean}(\text{diag}(G))=1$
- Weight A-matrix: 10%
- `hginv_lapack_para`

# Validation: Interbulls GEBV-test

- Masking 5 year of data.
- Prediction of GEBVs on reduced data set
- Compare with DYDs
- Weighted linear regression

	Milk		Fat%		Protein%	
	R <sup>2</sup>	$\beta$	R <sup>2</sup>	$\beta$	R <sup>2</sup>	$\beta$
org	0.573	1.02	0.63	0.96	0.699	1.11



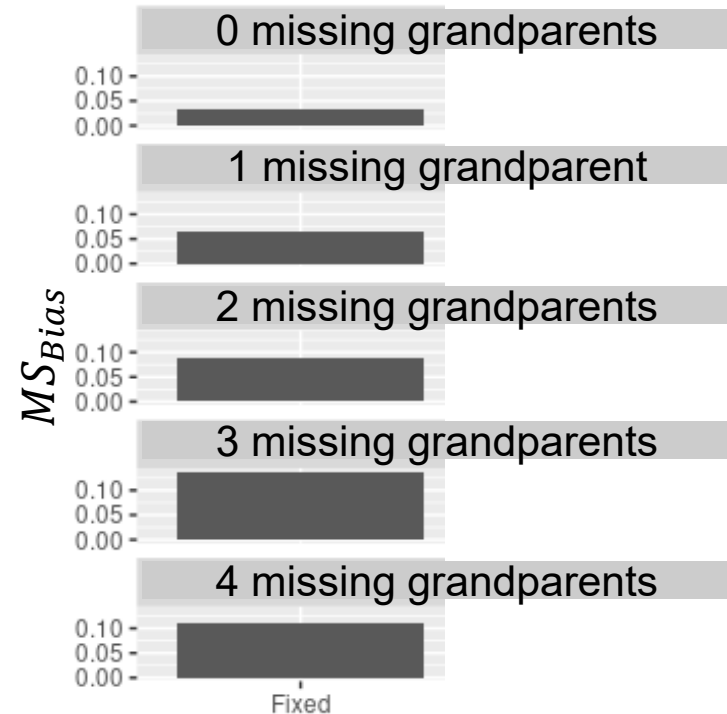
- Level-bias  $\approx 0$  (average change in EBV when being genotyped)

# Validation: Mendelian sampling?

- Compare EBVs with parentage average for groups of animals.

$$MS_{Bias} = \text{Mean} \left( \frac{EBV - 0.5(EBV_p + EBV_m)}{\sigma_g} \right)$$

- Genotyped animals or animals with genotyped offspring
- Method for fitting genetic groups
  - Fixed effects
  - Random effect



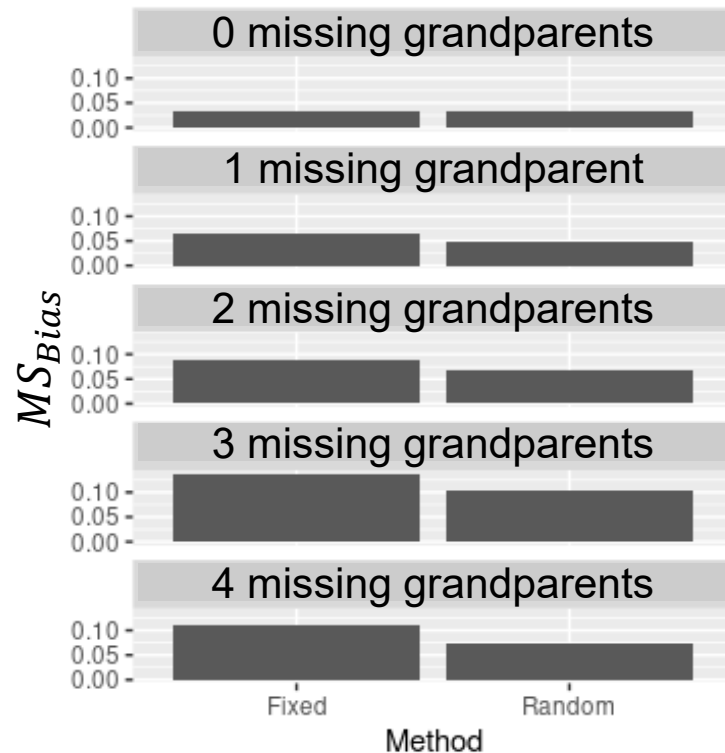
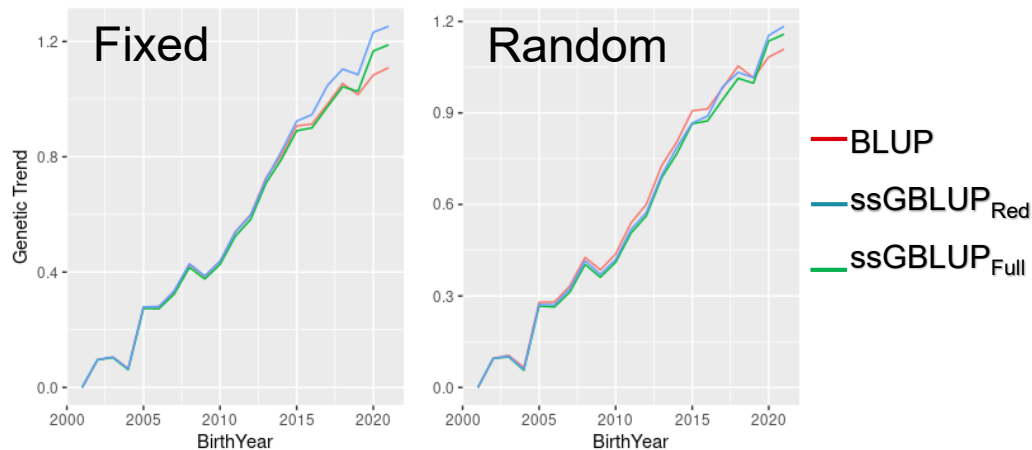


# Genetic groups as random effect ( $\sigma_G^2$ ) vs. fixed

## Interbulls GEBV-test:

	Milk		Fat%		Protein%	
	R <sup>2</sup>	$\beta$	R <sup>2</sup>	$\beta$	R <sup>2</sup>	$\beta$
Fixed	0.573	1.02	0.63	0.96	0.699	1.11
Random	0.574	1.02	0.63	0.96	0.700	1.11

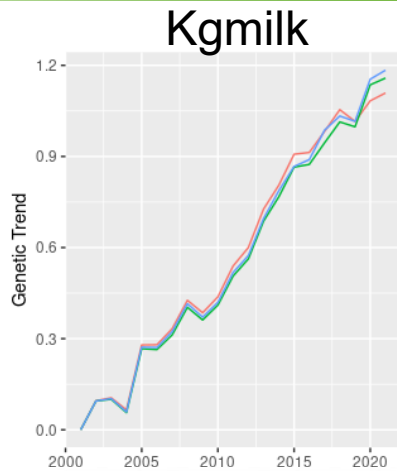
## Level-bias $\approx 0$





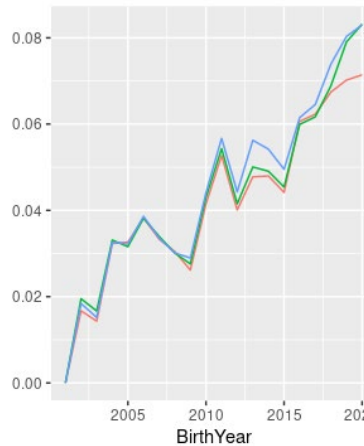
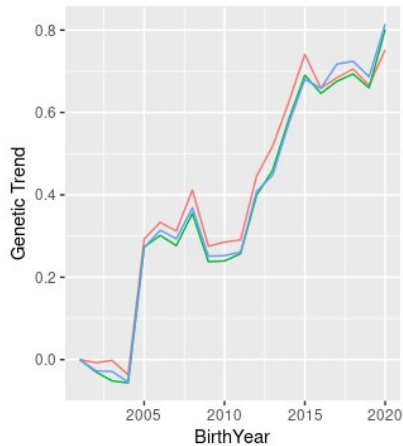
# Genetic Trends

All animals



— BLUP  
— ssGBLUP<sub>Red</sub>  
— ssGBLUP<sub>Full</sub>

Genotyped animals





# Acknowledgements

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- The Research Council of Norway
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A close-up, high-contrast photograph of a horse's eye. The eye is dark and partially visible, with long, dark eyelashes extending downwards. The surrounding skin and fur are dark and textured. The word "QUESTIONS?" is overlaid in white, bold, sans-serif capital letters in the center-right of the image.

QUESTIONS?