

# Effect of genotyping strategies on the sustained genetic gain across multiple generations of selection using ssGBLUP

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THE UNIVERSITY  
of EDINBURGH

# **single step GBLUP (ssGBLUP)**

- I. Information of genotyped and not genotyped animals is used in a joint analysis.
- II. Genotype information (should) propagates across all animals. Also, improving the accuracy of ungenotyped candidates.

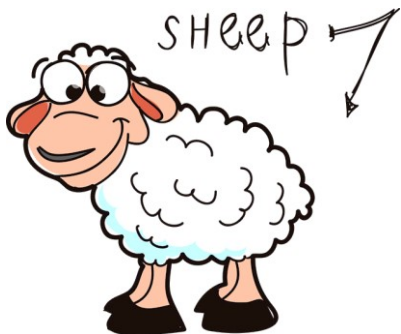
**IF NOT ALL CANDIDATES ARE GOING TO BE GENOTYPED, IT IS NEEDED TO OPTIMISE GENOTYPING STRATEGY TO MAXIMISE THE BENEFIT OF GENOMIC SELECTION.**

- ☐ Optimise the reference population.
- ☐ Optimise the list of genotyped candidates.

## **Main Aim:**

**To quantify the impact of  
genotyping strategy\* on the  
sustained genetic gain across  
multiple generations using  
ssGBLUP.**

**(\*genotyping of candidates)**



# Founder Population in LD

(Genotype in mutation-drift equilibrium algorithm)

**Initial Population**  
**N=100**

Creation of LD  
10,000 gen.

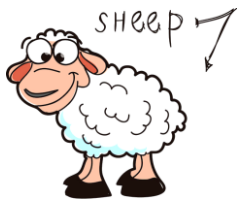
**Population in LD**

- 500,000 loci/chr.  
- Mutation rate  $10e-06$ .

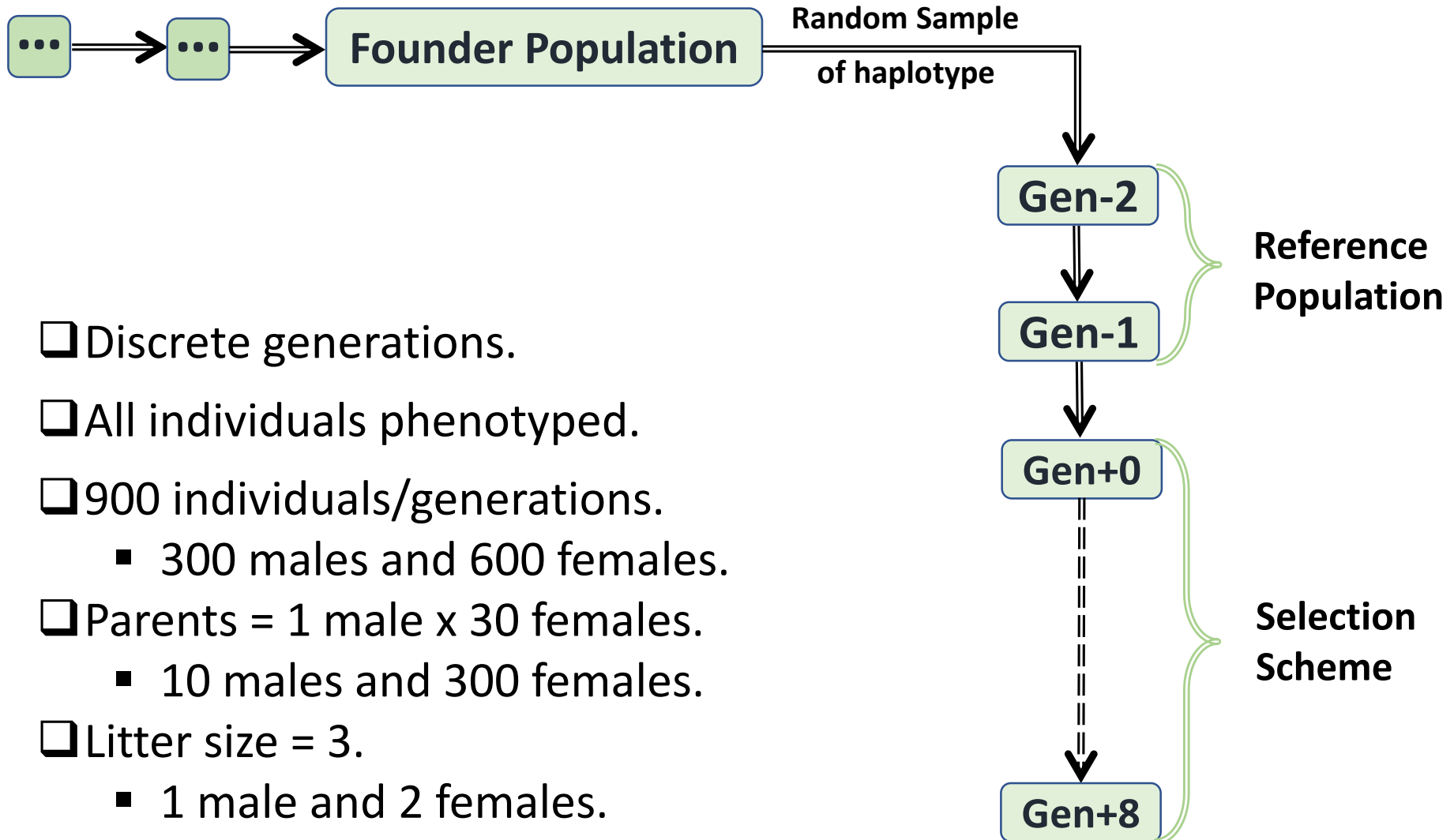
- 5,000 segregating loci/chr.

**Founder Population**  
**N = 4000**

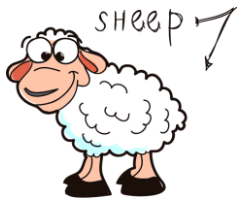
Expansion  
3 generations.



# Population Structure



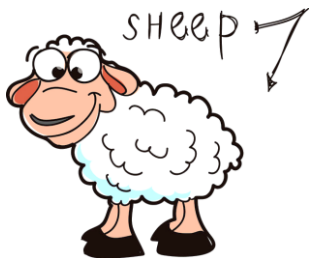
- ☐ Discrete generations.
- ☐ All individuals phenotyped.
- ☐ 900 individuals/generations.
  - 300 males and 600 females.
- ☐ Parents = 1 male x 30 females.
  - 10 males and 300 females.
- ☐ Litter size = 3.
  - 1 male and 2 females.



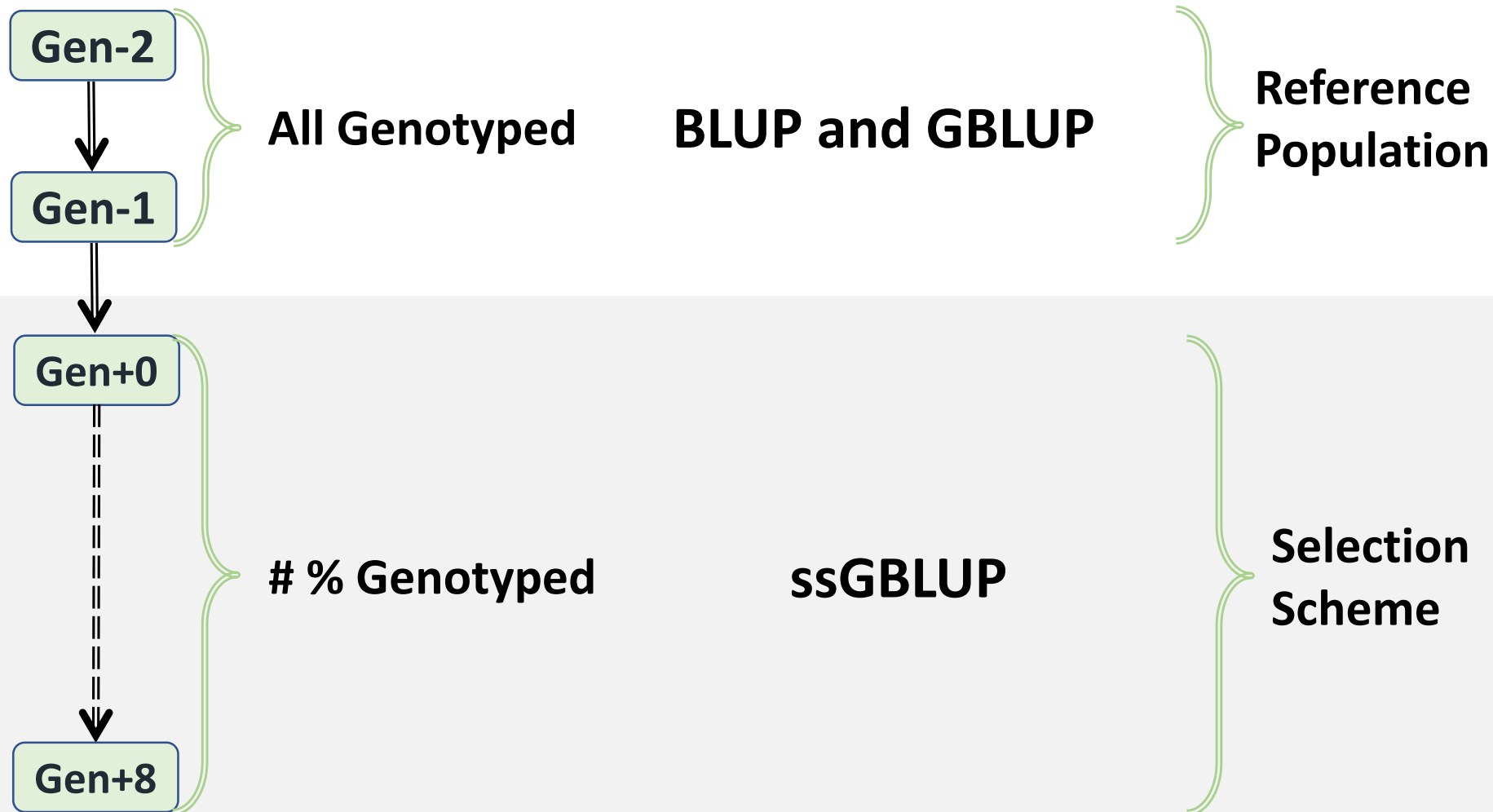
# Genetic Architecture



- ☐ Heritability = 0.2.
  - ☐ 26 Autosomal chromosomes.
  - ☐ Chip panel 1,000 SNPs/chr.
    - 26,000 SNPs.
  - ☐ 100 QTLs/chr.
    - 2,600 QTLs.
- ☐ SNP/QTL loci and effects resampled at each replicates (100 replicates).



# Genetic and Genomic Evaluation



# Genotyping Strategies Scenarios in ssGBLUP

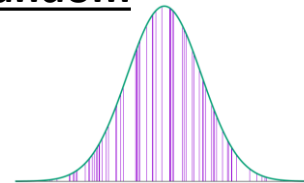
## ☐ Proportion of genotyped candidates in ssGBLUP

- 10%, 20%, 30%, 40%, 50%, 70%

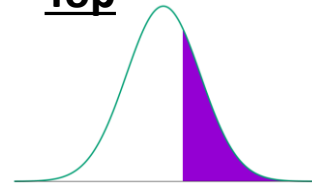
## ☐ Genotyping protocols based on phenotype

- Random candidates
- Top candidates
- Extreme candidates

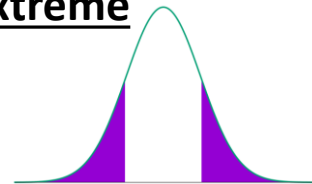
Random



Top



Extreme



## ☐ Compared relative to BLUP and GBLUP

- Proportion = 0% and 100 %



# Measuring ssGBLUP Performance

Criteria to measure performance:

- Genetic Gain
- Reliability

**Efficiency: benefit of ssGBLUP over BLUP as proportion of benefit observed with GBLUP.**

$$\text{Efficiency} = \frac{(\text{ssGBLUP} - \text{BLUP})}{(\text{GBLUP} - \text{BLUP})}$$

**Range of ssGBLUP efficiency**

- Upper limit = GBLUP
- Lower limit = BLUP

**Efficiency = 0. ssGBLUP same as BLUP**

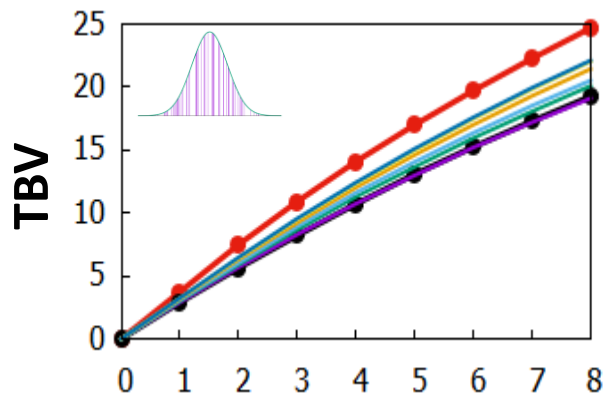
**Efficiency = 1. ssGBLUP same as GBLUP**

# **RESULTS**

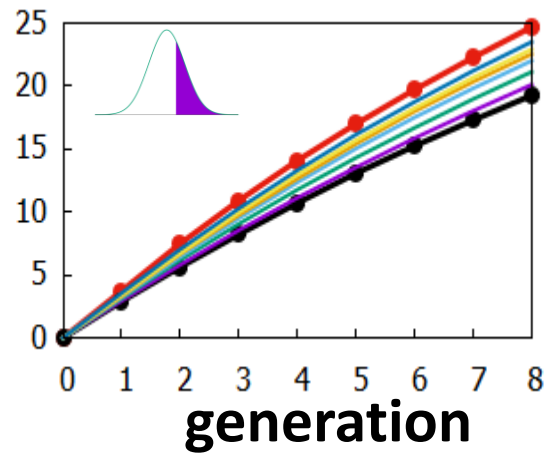
**Based in 100 replicates**

# Genetic Response with ssGBLUP

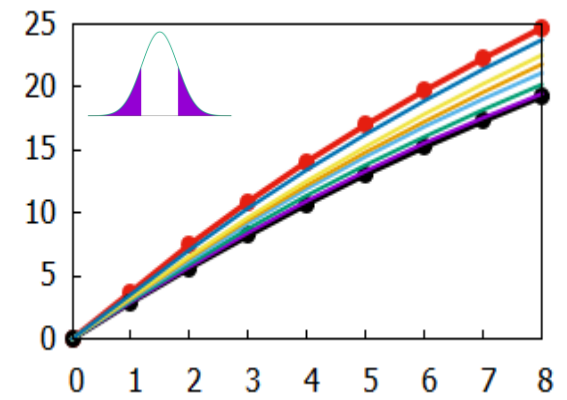
Random



Top



Extreme



GBLUP

ssGBLUP 70%

ssGBLUP 40%

ssGBLUP 20%

BLUP

ssGBLUP 50%

ssGBLUP 30%

ssGBLUP 10%

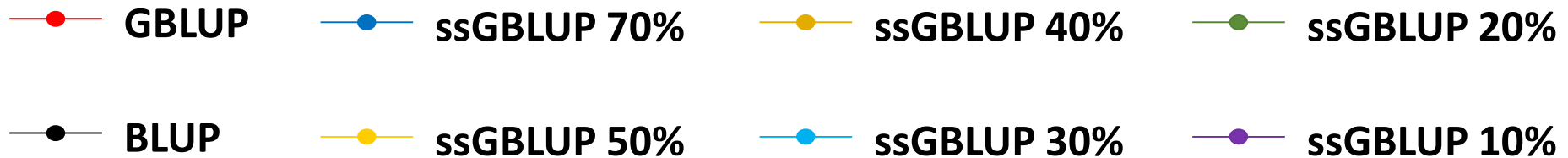
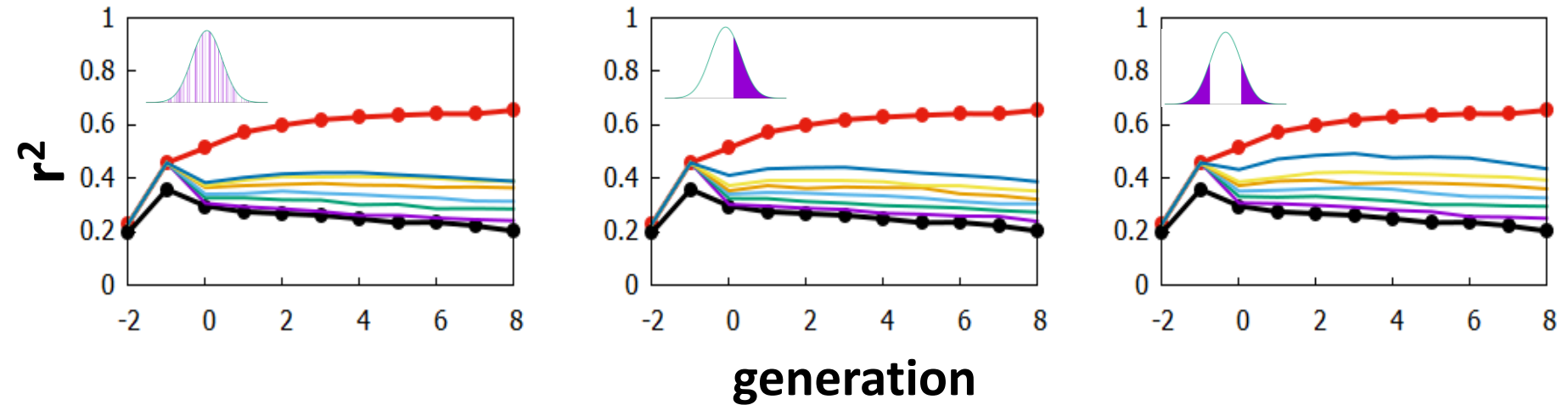
Mean of 100 replicates

# Overall Reliability with ssGBLUP

Random

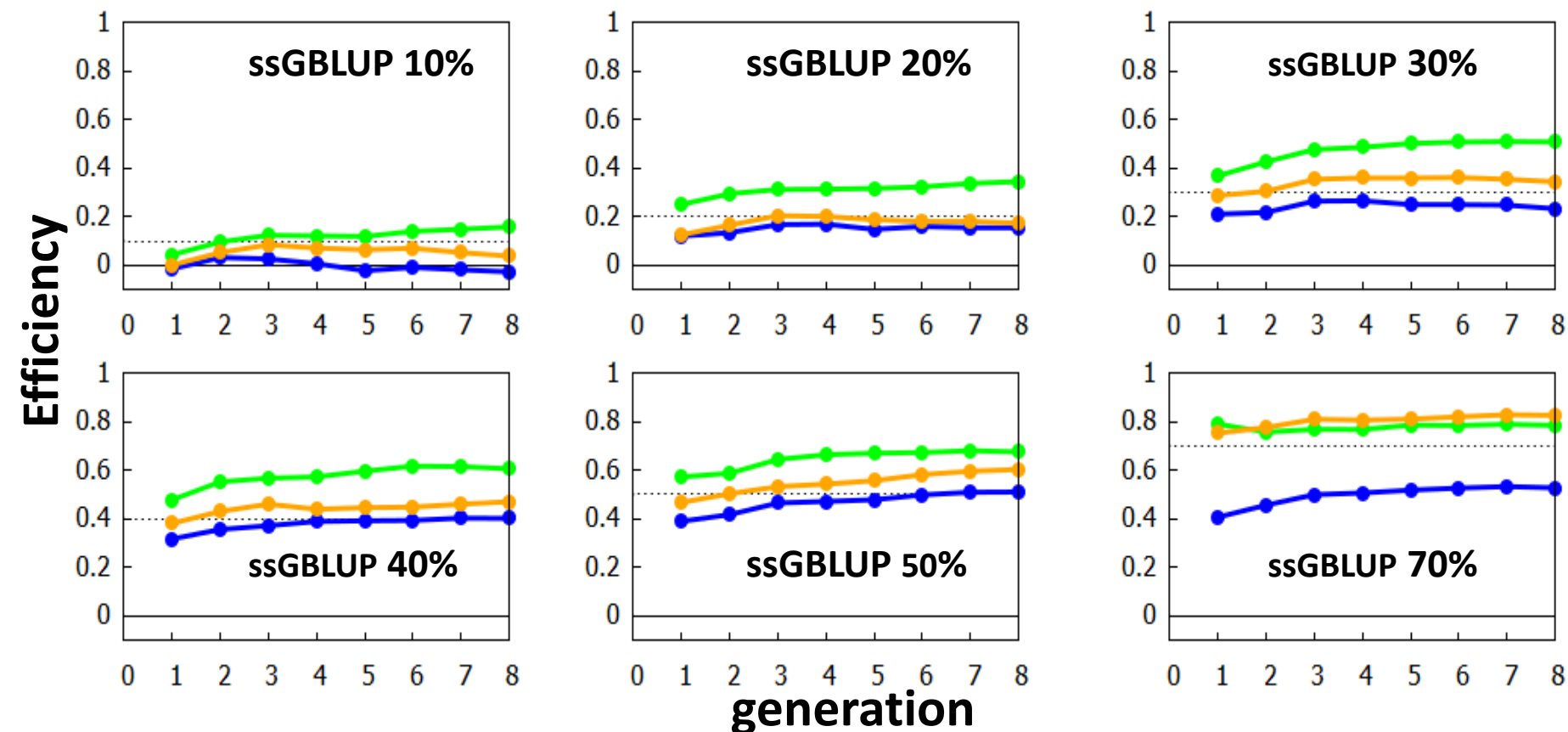
Top

Extreme



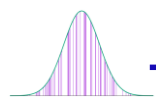
Mean of 100 replicates

# Efficiency of ssGBLUP on Genetic Gain

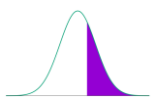


$$\text{Efficiency} = \frac{(\text{ssGBLUP} - \text{BLUP})}{(\text{GBLUP} - \text{BLUP})}$$

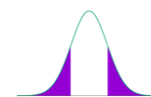
**TOP ≥ Extreme ≥ Random**



—●— Random

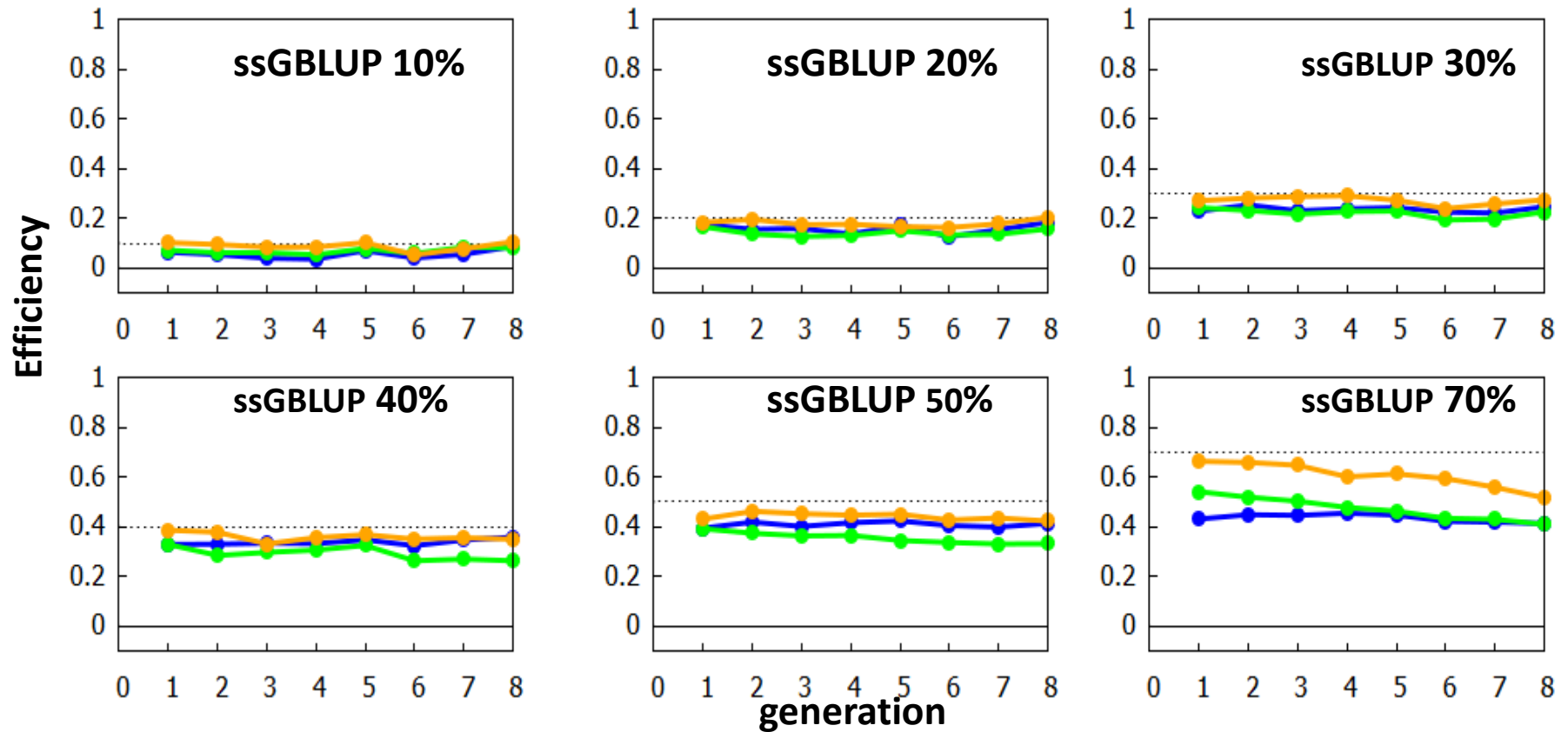


—●— Top



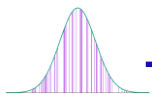
—●— Extreme

# Efficiency of ssGBLUP on the Overall Reliability

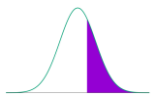


$$\text{Efficiency} = \frac{(\text{ssGBLUP} - \text{BLUP})}{(\text{GBLUP} - \text{BLUP})}$$

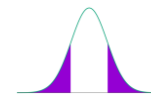
**EXTREME >> RANDOM > TOP**



—●— Random



—●— Top



—●— Extreme

????????????

❑ **Genetic Gain**

▪  **$TOP \geq EXTREME \geq RANDOM$**

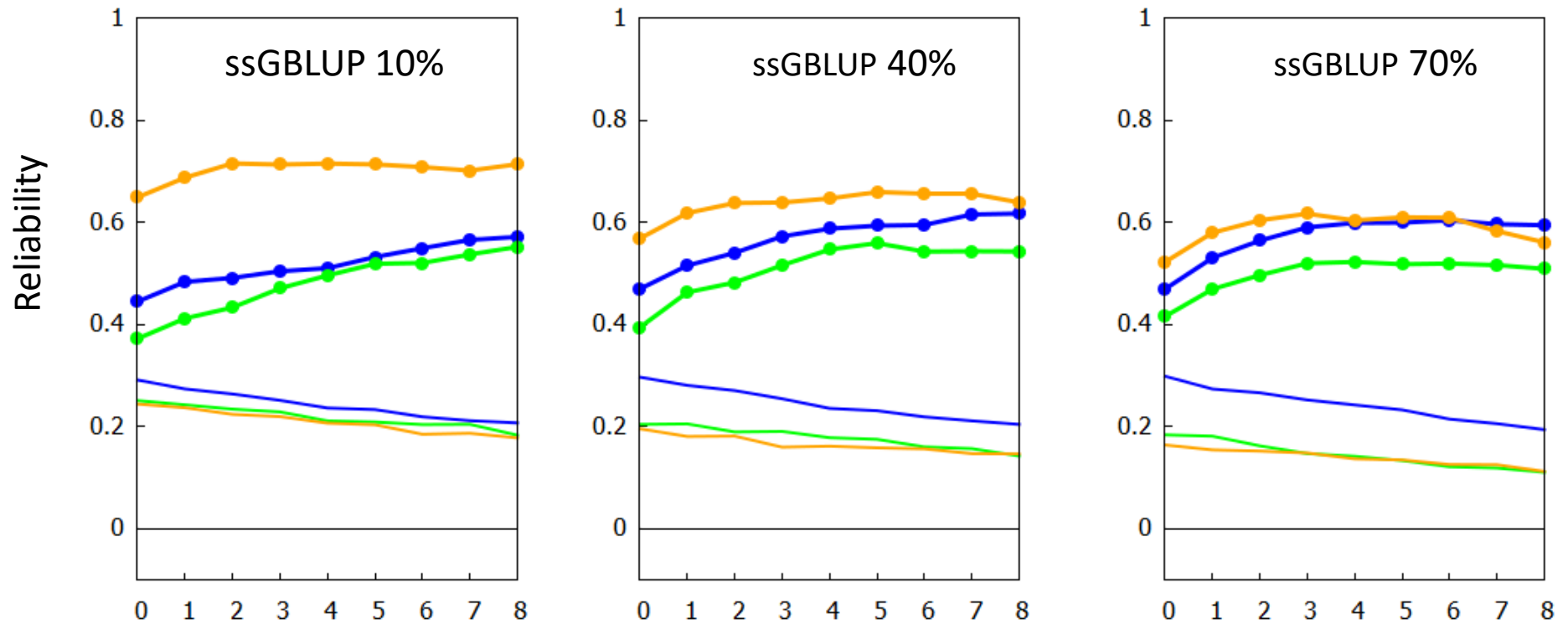
❑ **Overall Reliability**

▪  **$EXTREME \gg RANDOM > TOP$**

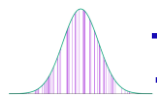
**And this does not make sense because  
In Discrete Generation, the expectation is that:  
Extra genetic gain MUST be due to better prediction.  
Therefore, you expect that the strategy of greater reliability should have greater genetic gain.**

# ssGBLUP Reliability

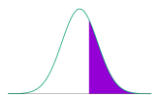
## genotyped and non-genotyped candidates



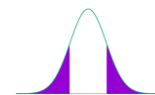
**EXTREME >> RANDOM > TOP**



● Genotyped  
— Non-genotyped



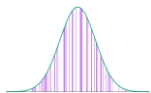
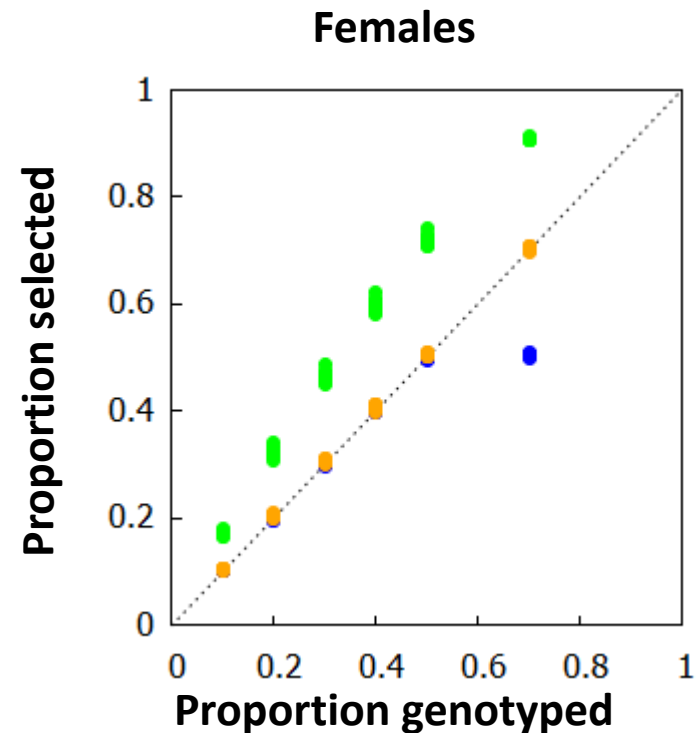
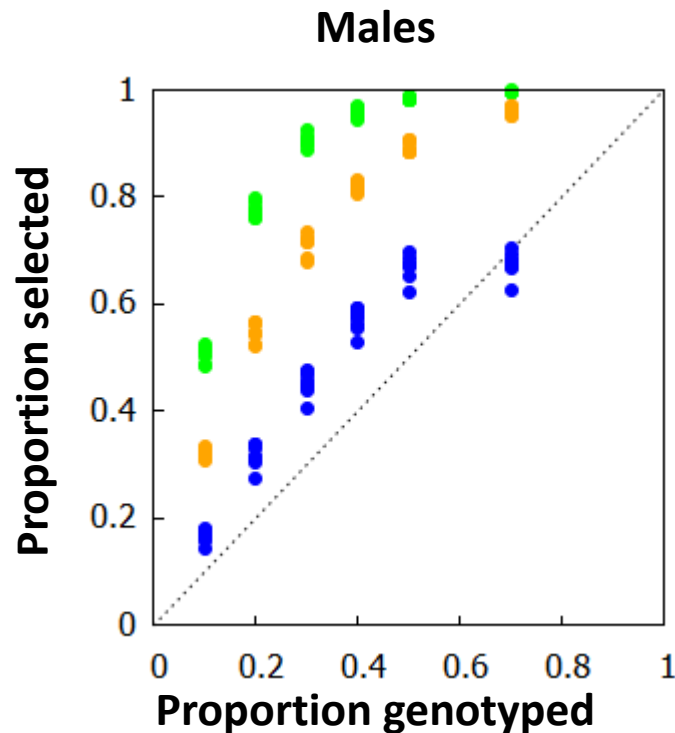
● Genotyped  
— Non-genotyped



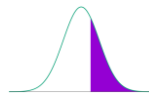
● Genotyped  
— Non-genotyped



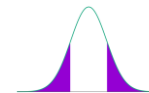
# Proportion of selected candidates being genotyped



Random



Top



Extreme

**TOP has greater proportion of genotyped candidates being selected**

# CONCLUSIONS

- ❑ The benefit of ssGBLUP was similar across generations.
- ❑ The benefit of ssGBLUP increases almost linearly with proportion of the genotyped candidates.
- ❑ Genotyping strategy protocol affects the ssGBLUP performance
  - Genetic gain:
    - $TOP \geq EXTREME \geq RANDOM$
    - EXTREME DEPENDS ON PROPORTION GENOTYPED
      - Extreme = Top with high proportion
      - Extreme = random with low proportion
  - Reliability:
    - $EXTREME \gg RANDOM > TOP$
    - Needed to be further tested to ensure it is not an artefact
  - Proportion genotyped being selected:
    - $TOP > EXTREME > RANDOM$

Thank you very much for you attention.



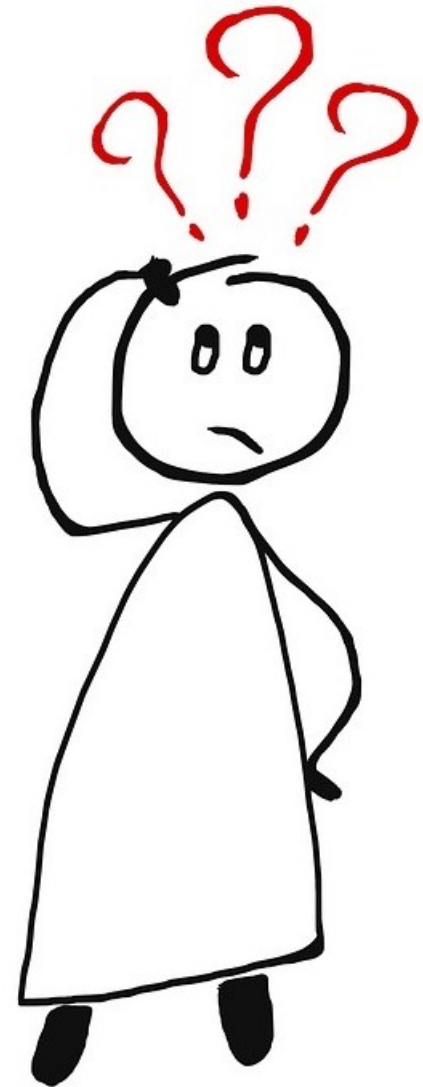
## □ Acknowledgment:

Mila Sánchez-Mayor is founded by FPI from MINECO (Ref. BES-2013-063614) and AGL2015-66035-R project.

Ricardo Pong-Wong is founded by BBSRC (BBS/E/D/30002275) and SMARTER (EU772787)

**Do you have any  
questions?**

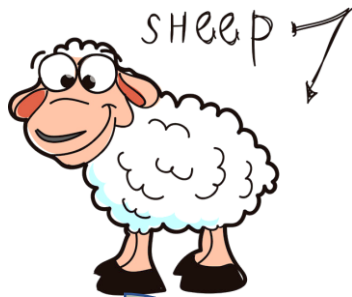
**Please, in the  
simplest English you  
can speak!**



# Simulation

n

## Population Structure



Maternal  
half-sib

Paternal  
half-sib



26

Discrete generation:

- Benefit of Genomic Selection on Accuracy.
- No effect on the generation interval.
- Litter size 3 (1 male and 2 female)
  - Minimum number per sex and still have selection.