Improving mating plans at herd level using genomic information

MARIE BERODIER

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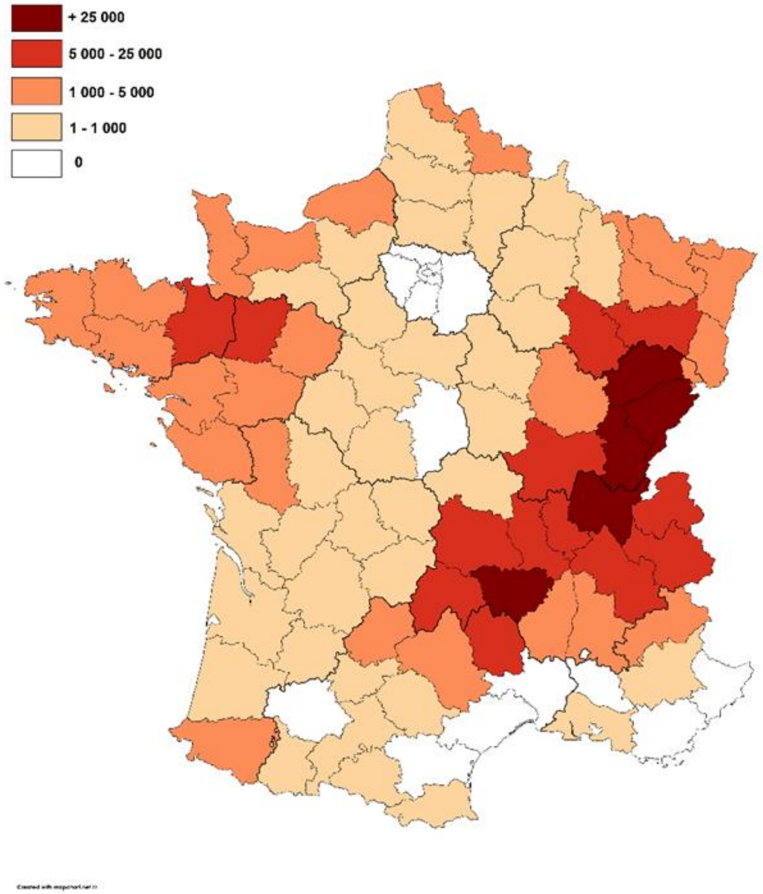
Study funded by Mo3

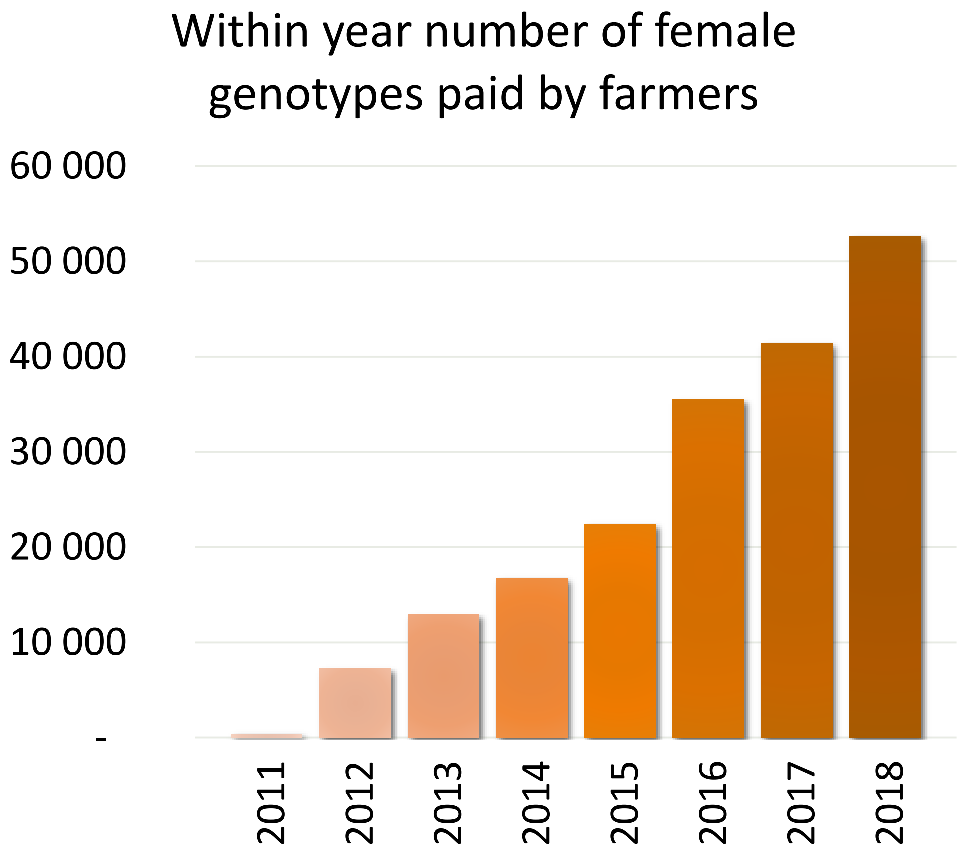
The Montbéliarde breed in France



In 2018

- Dual purpose breed
- 2nd dairy breed in France
  - 17.9 % of French dairy cattle
  - 427 748 lactations recorded

Female genotyping opportunities



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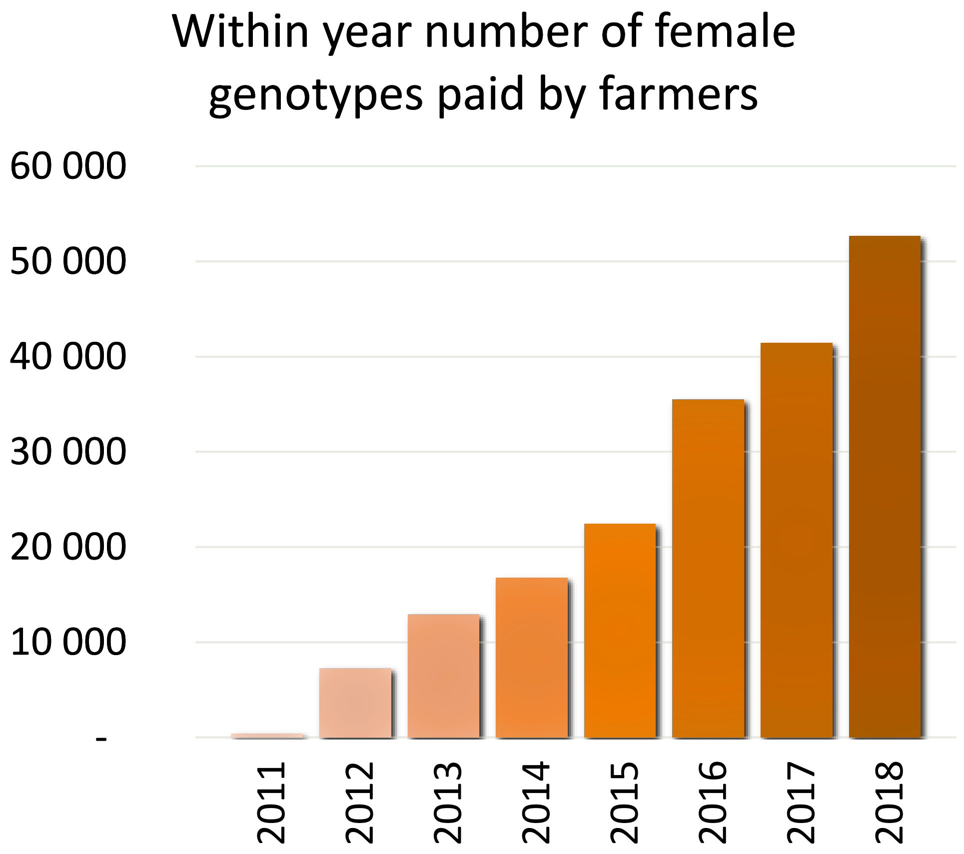

In mating plans:

➔ Genomic EBVs (GEBVs)

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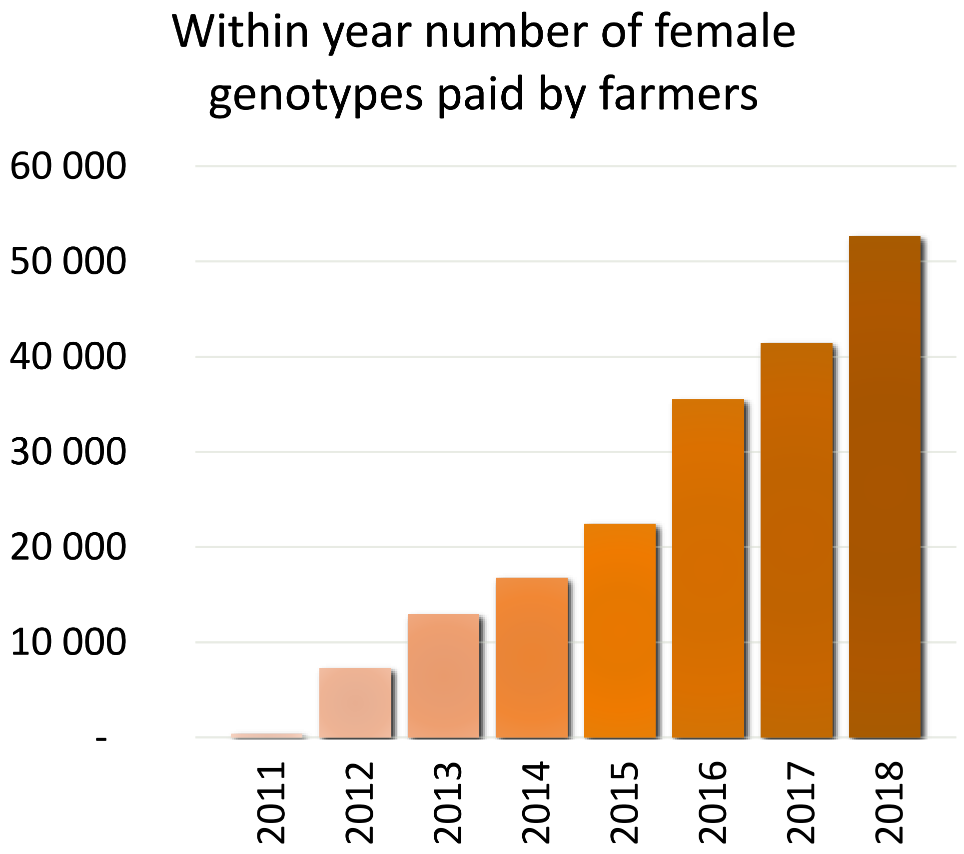

In mating plans:

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- Genomic co-ancestry

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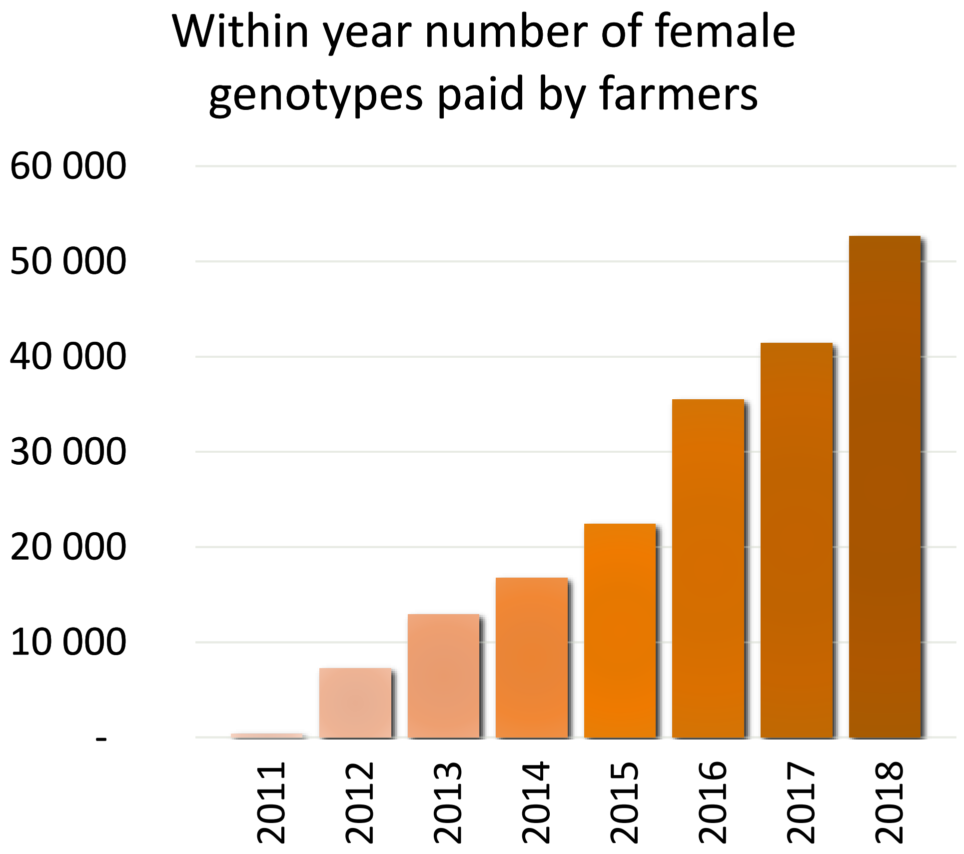

In mating plans:

- ➔ Genomic EBVs (GEBVs)
- ➔ Genomic co-ancestry
- ➔ True carrier status for genetic defects

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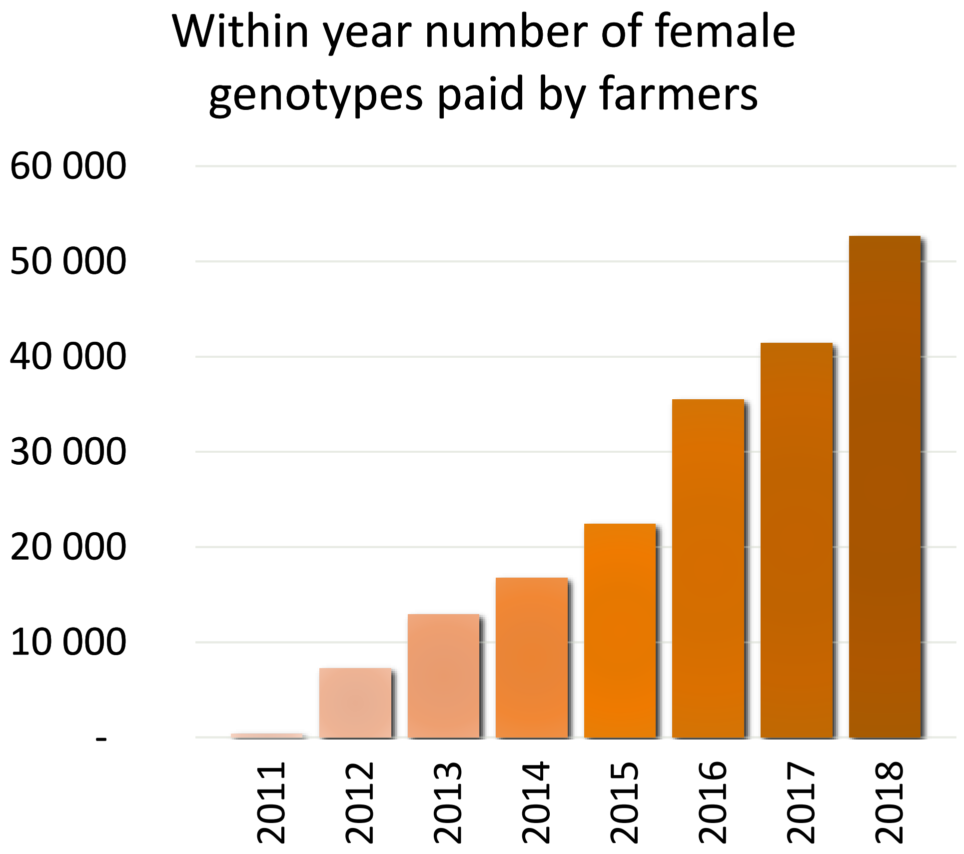

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Can female genomic information improve mating plans in commercial farms?

Material and Methods – Real data

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→ 9 143 females in 160 herds

Material and Methods – Objective

Objective : Maximize expected economic score of the offspring

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Average mates
Net Merit (€)

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Objective function: $\mathbf{Score}_{ij} = \left(0.5\left(\mathbf{NM_i} + \mathbf{NM_j}\right) + \lambda \mathbf{F_{ij}} \right)$

Average mates Net Merit (€)

Expected progeny inbreeding (€)

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- $0.5\left(NM_i + NM_j\right)$: Average mates Net Merit (€)
- λF_{ij}: Expected progeny inbreeding (€)
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- $prob(♀)$: Probability to conceive a female fetus
- $p(aa)_r$: Probability to conceive a fetus affected by the genetic defect *r*, $r \in \{MH1\,;MH2\,;MTCP\}$
- v_r: Economic loss associated with *r* (€)

Material and Methods – Mating & constraints

Global constraints

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Material and Methods – Mating & constraints

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Material and Methods – Mating & constraints

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Material and Methods – Mating & constraints

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- Max 10% of the females of a herd per bull

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	M 1	M 2	M 3	M 4	M 5	M 6
F 1	207	241	-69	145	95	77
F 2	147	272	151	23	-53	105
F 3	41	248	56	0	-51	163
F 4	286	176	244	-12	256	300
F 5	-19	19	13	42	195	-16
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Cows	F 4	286	176	244	-12	256	300
	F 5	-19	19	13	42	195	-16
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- Linear programing

Mo3 Plateforme Innovation — Ecole Doctorale ABIES — Cifre — AgroParisTech — INRA Science & Impact

Results – Mating advice

Average economic score (€)
Average Net Merit (€)
Average genomic co-ancestry (%)
Probability of calf loss due to a genetic defect (%)
Max. genomic co-ancestry (%)

Results – Mating advice

	Farmers current plans
Average economic score (€)	
Average Net Merit (€)	
Average genomic co-ancestry (%)	
Probability of calf loss due to a genetic defect (%)	
Max. genomic co-ancestry (%)	

Actual farmers mating plans in summer – autumn 2018

Results – Mating advice

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	Farmers current plans	RANDOM	Genomic Sequential Score	Genomic Linear Pro. Score
Average economic score (€)	175.5			
Average Net Merit (€)	394.8			
Average genomic co-ancestry (%)	6.3			
Probability of calf loss due to a genetic defect (%)	1.8			
Max. genomic co-ancestry (%)	-			

Results – Mating advice

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	Farmers current plans	RANDOM	Genomic Sequential Score	Genomic Linear Pro. Score
Average economic score (€)	175.5	150	218.7	223.9
Average Net Merit (€)	394.8	390.9	436.3	437.1
Average genomic co-ancestry (%)	6.3	7	5.2	5
Probability of calf loss due to a genetic defect (%)	1.8	1.15	0.2	0.15
Max. genomic co-ancestry (%)	-	31.9	16.5	14.6

Linear programing > Sequential > Actual > Random

Results – Mating advice

	Farmers current plans	RANDOM	Genomic Sequential Score	Genomic Linear Pro. Score	Pedigree Linear Pro. Score
Average economic score (€)	175.5	150	218.7	223.9	
Average Net Merit (€)	394.8	390.9	436.3	437.1	
Average genomic co-ancestry (%)	6.3	7	5.2	5	
Probability of calf loss due to a genetic defect (%)	1.8	1.15	0.2	0.15	
Max. genomic co-ancestry (%)	-	31.9	16.5	14.6	

Hypothesis: Only pedigree information from females

Results – Mating advice

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	Farmers current plans	RANDOM	Genomic Sequential Score	Genomic Linear Pro. Score	Pedigree Linear Pro. Score
Average economic score (€)	175.5	150	218.7	223.9	201.4
Average Net Merit (€)	394.8	390.9	436.3	437.1	436.6
Average genomic co-ancestry (%)	6.3	7	5.2	5	6.2
Probability of calf loss due to a genetic defect (%)	1.8	1.15	0.2	0.15	0.37
Max. genomic co-ancestry (%)	-	31.9	16.5	14.6	13.6

Genomic > Pedigree

Results – Mating advice

	Farmers current plans	RANDOM	Genomic Sequential Score	Genomic Linear Pro. Score	Pedigree Linear Pro. Score	Genomic Linear Pro. Net Merit
Average economic score (€)	175.5	150	218.7	223.9	201.4	
Average Net Merit (€)	394.8	390.9	436.3	437.1	436.6	
Average genomic co-ancestry (%)	6.3	7	5.2	5	6.2	
Probability of calf loss due to a genetic defect (%)	1.8	1.15	0.2	0.15	0.37	
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Hypothesis: Optimization on Net Merit only (≠ score)

Results – Mating advice

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	Farmers current plans	RANDOM	Genomic Sequential Score	Genomic Linear Pro. Score	Pedigree Linear Pro. Score	Genomic Linear Pro. Net Merit
Average economic score (€)	175.5	150	218.7	223.9	201.4	189.6
Average Net Merit (€)	394.8	390.9	436.3	437.1	436.6	445.5
Average genomic co-ancestry (%)	6.3	7	5.2	5	6.2	7.1
Probability of calf loss due to a genetic defect (%)	1.8	1.15	0.2	0.15	0.37	0.58
Max. genomic co-ancestry (%)	-	31.9	16.5	14.6	13.6	31.2

Economic score > Net Merit only

Results – Mating advice

	Farmers current plans	RANDOM	Genomic Sequential Score	**Genomic Linear Pro. Score**	Pedigree Linear Pro. Score	Genomic Linear Pro. Net Merit	**Gen. Lin.P. Bulls all sem. type**
Average economic score (€)	175.5	150	218.7	223.9	201.4	189.6	
Average Net Merit (€)	394.8	390.9	436.3	437.1	436.6	445.5	
Average genomic co-ancestry (%)	6.3	7	5.2	5	6.2	7.1	
Probability of calf loss due to a genetic defect (%)	1.8	1.15	0.2	0.15	0.37	0.58	
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Hypothesis: Bulls available with both sexed and conventional semen

Results – Mating advice

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Average economic score (€)	175.5	150	218.7	223.9	201.4	189.6	231.3
Average Net Merit (€)	394.8	390.9	436.3	437.1	436.6	445.5	441.3
Average genomic co-ancestry (%)	6.3	7	5.2	5	6.2	7.1	4.7
Probability of calf loss due to a genetic defect (%)	1.8	1.15	0.2	0.15	0.37	0.58	0.11
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➔ Semen type availability can improve mating choice

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Hypothesis: Coancestry limited to 8.5%

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➔ Constraining co-ancestry has small negative impact on other parameters

Results – Mating advice

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➔ Genomic information can improve current plans

Take home messages

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- Mating methods are fast → applicable on farm

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- Mating methods are fast → applicable on farm
- Genomic information allows for better mating plans than pedigree information only
  - -19% co-ancestry & -2.5 fold of fetus affected by a genetic defect

Take home messages

- Genomic information can improve current mating plans
- Mating methods are fast → applicable on farm
- Genomic information allows for better mating plans than pedigree information only
  - -19% co-ancestry & -2.5 fold of fetus affected by a genetic defect
- Not accounting for co-ancestry and probability to conceive a fetus affected by a genetic defect leads to under-optimized mating solutions

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- Genomic information can improve current mating plans
- Mating methods are fast → applicable on farm
- Genomic information allows for better mating plans than pedigree information only
  - -19% co-ancestry & -2.5 fold of fetus affected by a genetic defect
- Not accounting for co-ancestry and probability to conceive a fetus affected by a genetic defect leads to under-optimized mating solutions
- Type of semen must be accounted for when planning the matings

Material and Methods – Objective

Objective : Maximize expected economic score of the offspring

Objective function: $\mathbf{Score}_{\mathbf{ij}} = \left(0.5\left(\mathbf{NM_i} + \mathbf{NM_j}\right) + \boldsymbol{\lambda}\mathbf{F_{ij}}\right) \times \mathbf{prob}(♀) + \sum_{\mathbf{r=1}}^{\mathbf{n_r}} \mathbf{p(aa)_r} \times \mathbf{v_r}$

- $Score_{ij}$: expected economic added value of the offspring from female i and bull j
- NM: GEBV for Net Merit trait
- $\boldsymbol{\lambda}$: economic value associated to 1% of inbreeding (€)
- F_{ij}: expected inbreeding of the offspring from female i and bull j
- prob(♀): probability to conceive a female fetus. (0.5 with conventional semen and 0.9 with sexed semen)
- $p(aa)_r$: probability to conceive a fetus homozygous for the deleterious recessive allele r
- v_r: economic value associated to the conception of a fetus affected by the genetic defect r

$$\mathbf{r} \in \{\mathbf{MH1}\ ;\mathbf{MH2}\ ;\mathbf{MTCP}\}$$