Improving mating plans at herd level using genomic information

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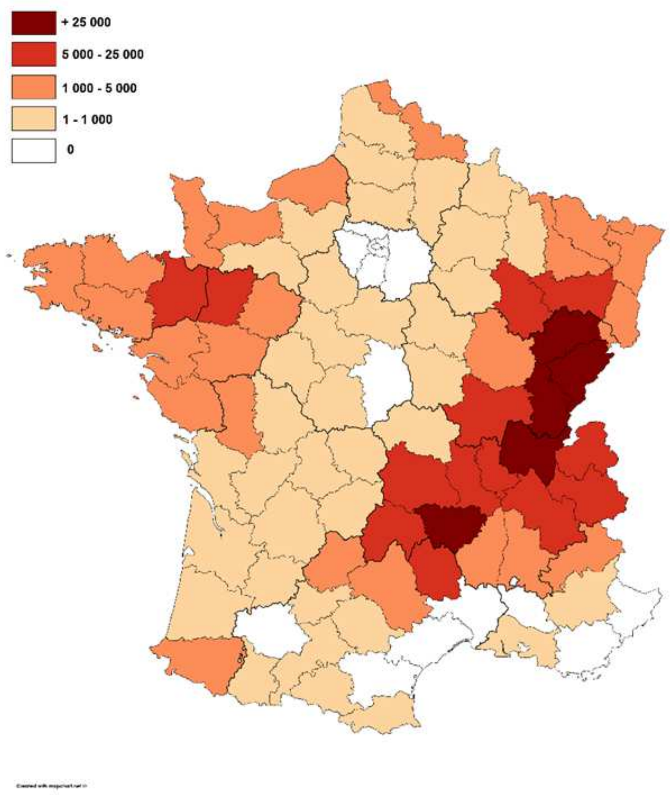
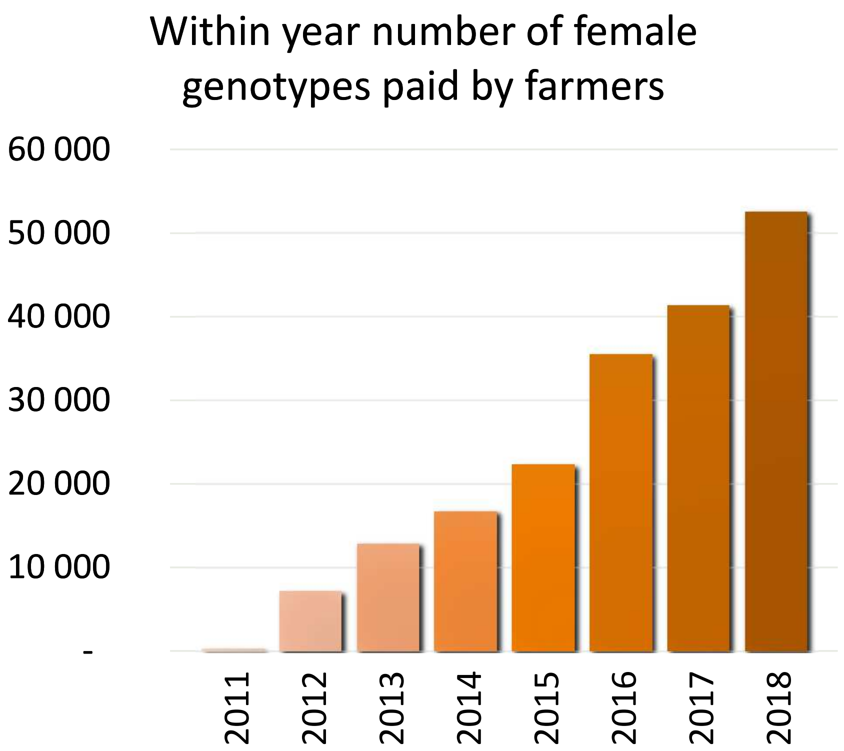
The Montbéliarde breed in France



In 2018

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

Female genotyping opportunities



In mating plans:

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

Can female genomic information improve mating plans in commercial farms?

Material and Methods – Real data

- Herds characteristics:
  - At least 20 calvings per year
  - >80% females to be mated are genotyped
  - Information on semen type (sexed, conventional or beef) as chosen by the farmer
- Males and females:
  - 54 Montbéliarde bulls (available in summer-autumn 2018)
  - Females Net Merit GEBV and EBV (own or from parental information)
  - Genomic AND pedigree co-ancestries for all potential mate pairs

➔ 9 143 females in 160 herds

Material and Methods – Objective

Objective : Maximize expected economic score of the offspring

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

- $0.5(NM_i + NM_j)$: Average mates Net Merit (€)
- λF_{ij}: Expected progeny inbreeding (€)
- $prob(♀)$: 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

- 1 mating per female

MATCH
- Female semen type ← farmer choice
- Male semen type ← availability

- Heifers with conventional semen
  → restriction for calving ease

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

Mating methods

- Random
- Sequential

		M 1	M 2	M 3	M 4	M 5	M 6
Heifers	F 1	207	241	-69	145	95	77
	F 2	147	272	151	23	-53	105
	F 3	41	248	56	0	-51	163
Cows	F 4	286	176	244	-12	256	300
	F 5	-19	19	13	42	195	-16
	F 6	181	15	260	176	-48	15

- Linear programing

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	
Max. genomic co-ancestry (%)	-	31.9	16.5	14.6	13.6	

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	
Max. genomic co-ancestry (%)	-	31.9	16.5	14.6	13.6	31.2	

Hypothesis: Bulls available with both sexed and conventional semen

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	Gen. Lin.P. Bulls all sem. type
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
Max. genomic co-ancestry (%)	-	31.9	16.5	14.6	13.6	31.2	14.6

➔ Semen type availability can improve mating choice

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	Gen. Lin.P. co-anc 8.5
Average economic score (€)	175.5	150	218.7	223.9	201.4	189.6	241.3	
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	
Max. genomic co-ancestry (%)	-	31.9	16.5	14.6	13.6	31.2	14.6	

<u>Hypothesis</u>: Coancestry limited to 8.5%

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	Gen. Lin.P. Bulls all sem. type	**Gen. Lin.P. co-anc 8.5**
Average economic score (€)	175.5	150	218.7	223.9	201.4	189.6	231.3	223.7
Average Net Merit (€)	394.8	390.9	436.3	437.1	436.6	445.5	441.3	436.5
Average genomic co-ancestry (%)	6.3	7	5.2	5	6.2	7.1	4.7	4.9
Probability of calf loss due to a genetic defect (%)	1.8	1.15	0.2	0.15	0.37	0.58	0.11	0.16
Max. genomic co-ancestry (%)	-	31.9	16.5	14.6	13.6	31.2	14.6	8.5

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

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	Gen. Lin.P. Bulls all sem. type	Gen. Lin.P. co-anc 8.5
Average economic score (€)	175.5	150	218.7	223.9	201.4	189.6	231.3	223.7
Average Net Merit (€)	394.8	390.9	436.3	437.1	436.6	445.5	441.3	436.5
Average genomic co-ancestry (%)	6.3	7	5.2	5	6.2	7.1	4.7	4.9
Probability of calf loss due to a genetic defect (%)	1.8	1.15	0.2	0.15	0.37	0.58	0.11	0.16
Max. genomic co-ancestry (%)	-	31.9	16.5	14.6	13.6	31.2	14.6	8.5

➔ Genomic information can improve current plans

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
- Type of semen must be accounted for when planning the matings