European Association for Animal Production

Genetic determinism of maternal behaviour in sheep and relationship with lamb mortality

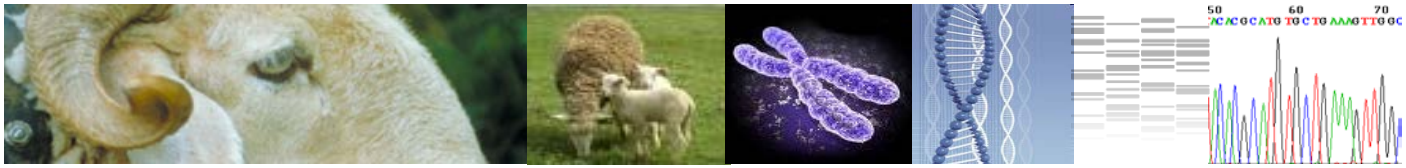
Dominique HAZARD[1]

Mace T. [1], Kempeneers A. [1], Foulquié D.[2], Carriere F.[2], Delval E.[3], Boissy A.[3]

[1]INRA UMR1388 GENPHYSE, 31326 Castanet-Tolosan, France
[2]INRA UE321 La Fage, 12250 Roquefort-sur-soulzon, France ;
[3]INRA UMR1213 Herbivores, 63122 Saint-Gènes-Champanelle, France

INRA SCIENCE & IMPACT

CONTEXT



Context

Global overview

1) Lamb mortality remains a major concern for sheep production.

2) Evolution of sheep farming systems includes :

- increased size of flock
- reduced support provided by human
- use of harsh environments

} unfavourable for lamb survival

Survival depends on the successful interaction between ewe and lamb.

→ • Improving of maternal behaviour can contribute to increase behavioural autonomy and lamb survival

Context

Genetic for maternal behavior (previous work in sheep)

- maternal behavior varies markedly between breeds in sheep

(Dwyer,2008, Boissy et al., 2005)

- genetic variability within breed poorly characterized
  - maternal behaviour score : $h^2<0.15$

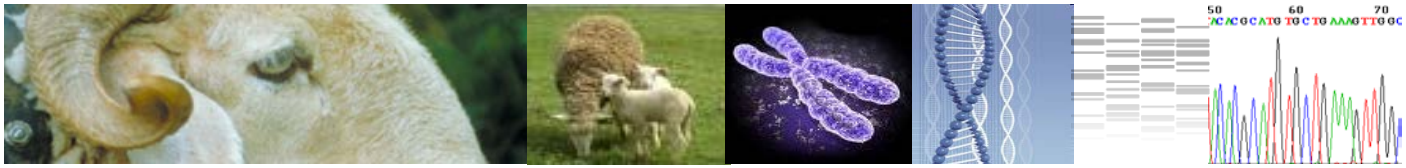
(Lambe et al. 2001, Everett-Hinks et al, 2005)

Genetic selection for maternal behaviour should offer opportunities for improving the behavioural autonomy of ewe and lamb survival.

Purpose of this study

To investigate genetic variability and to map QTL for maternal behavioural traits

Materials & Methods



Materials & Methods

Animal material:

- Romane breed (Berrichon x Romanov)
- flock raised outdoors all along the year
  fed on rangelands (1 ewe/ha)
  at the experimental farm La Fage (Roquefort)

- Genetic parameters :
  - 1285 phenotyped ewes (along 10 years)
  - recorded for 1 to 3 lambing

- QTL mapping:
  - 9 half-sib families (103 individuals per family)
  - n=933 genotypes and 470 phenotyped ewes

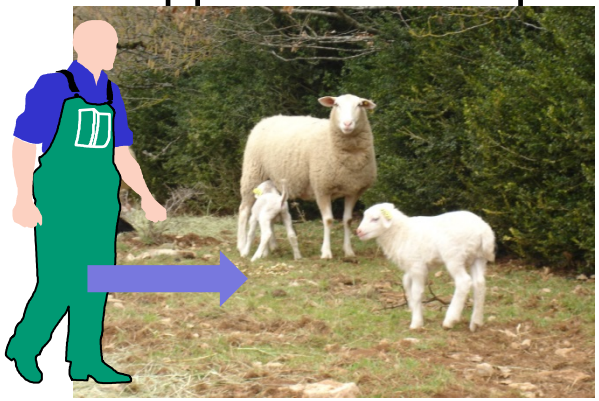
Materials & Methods

Two experimental tests for behavioural measurement :

Handling test (+2h)

Both tests aim to evaluate maternal attachment to the lamb

1. Approach of shepherd

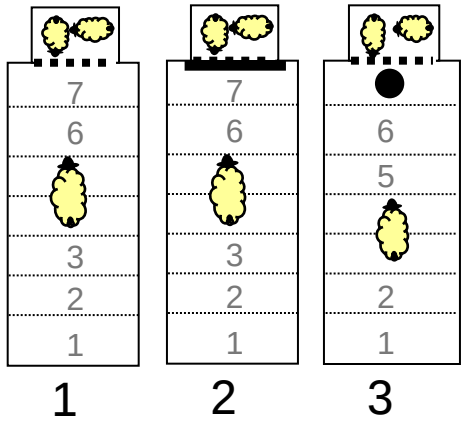


2. Handling of lambs

Shepherd leaves with lambs.

Arena test (+24h)

Unfamiliar enclosure (dirt floor, 2m high solid wooden walls, 7 zones)



1: litter behind a grid-barrier, ewe introduced

2: opaque panel pulled down to separate litter and ewe.

3: panel pulled up and a human enters and stays in front of the grid

Behaviours recorded during 1min (each phase).

Materials & Methods

Behavioural traits

Handling test

Approach (of the shepherd)

- Maternal Behaviour Score (MBS1)

1- ewe flees and does not return
2- ewe retreats and comes back
3- ewe retreats with lamb and comes back
4- ewe retreats and returns repeatedly
5- ewe stays close to the lambing area

Handling (of lambs by the shepherd)

- Maternal Behaviour Score (MBS2)

1- ewe flees
2- ewe stays close to the lambing area
3- ewe follows but keeping a distance
4- ewe follows staying close to the shepherd

Arena test 1/2/3

- High Bleats (number)
- Low Bleats (number)
- Locomotion (number of zones entered)
- Proximity score with the litter and the human

  (score computed depending upon time spent in different zones)

Materials & Methods

Genetic parameters

- Methodology: Variance and covariance components were estimated by restricted maximum likelihood (ASREML)
- Animal model: $Y_{ijklmn} = \mu + year_j + lsr_j + age_k + parity_l + ewe_m + animal_n + e_{ijklmno}$

Fixed effects | Environmental effect | Additive genetic effect

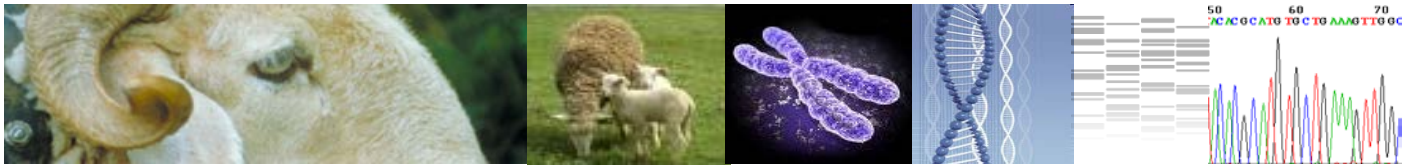
QTL mapping

- Genotyping : - Illumina OvineSNP50K beadchip

- SNP quality control (call rate, HW disequilibrium, MAF...)
- 43820 SNPs for analysis

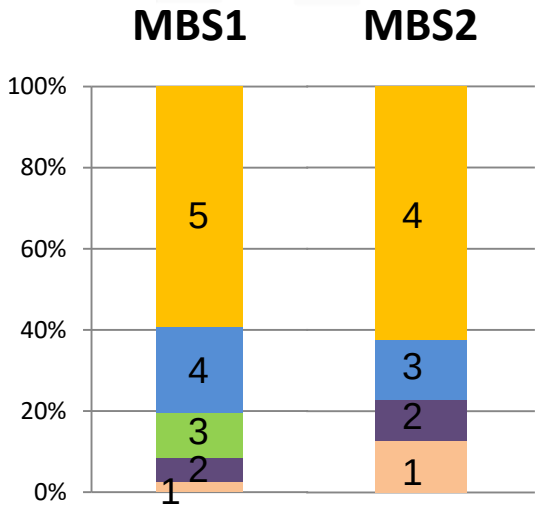
- Phenotypes: corrected for fixed effects, took into account repeated measurements
- Methodology: likelihood computation every 0.1 cM (QTLMAP)
  3 methods: - linkage analysis (LA)
  - association analysis (GWAS)
  - linkage and association joint analysis (LDLA)
- Thresholds computed with permutations

Results



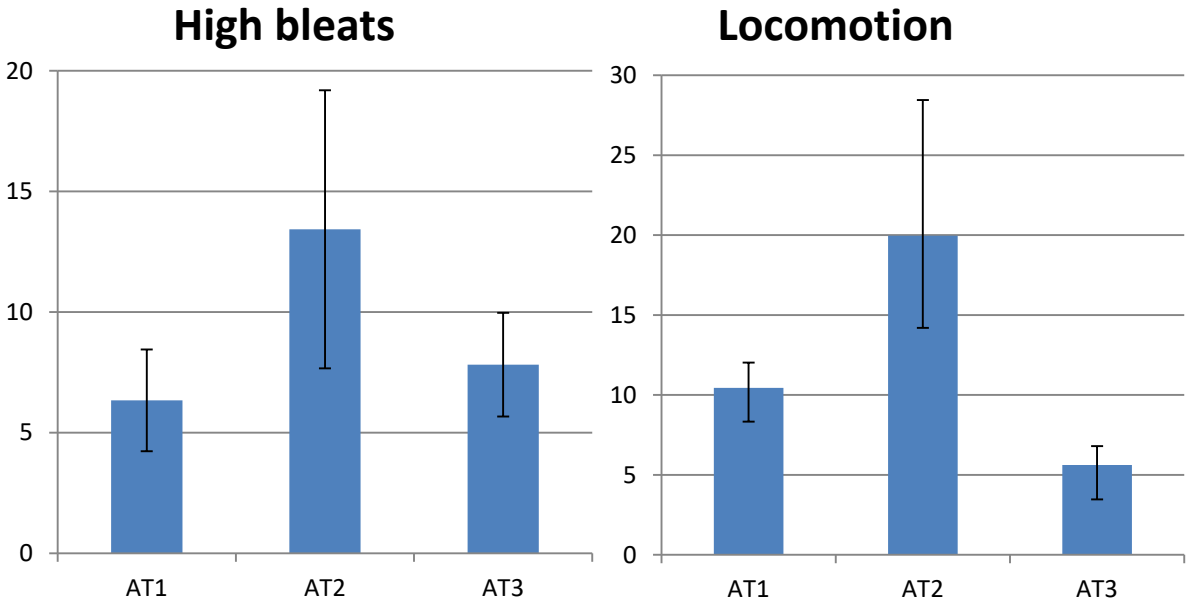
Results

Handling test



➢ Higher MBS represent the “better mothers”.

Arena test



➢ Higher reactive ewes to social separation are expected to be the “better mothers”.

➢ **Phenotypic variability for maternal reactivity to social separation from litter.**

Results

Genetic parameters

Handling test

	MBS1	MBS2
MBS1	0,23 +/- 0,06	0,82 +/- 0,13
MBS2		0,19 +/- 0,05
r	0,38 +/- 0,06	0,30 +/- 0,06

Diagonal: heritability; r, repeatability

➢ **Moderate to high heritability estimates for traits of maternal attachment.**

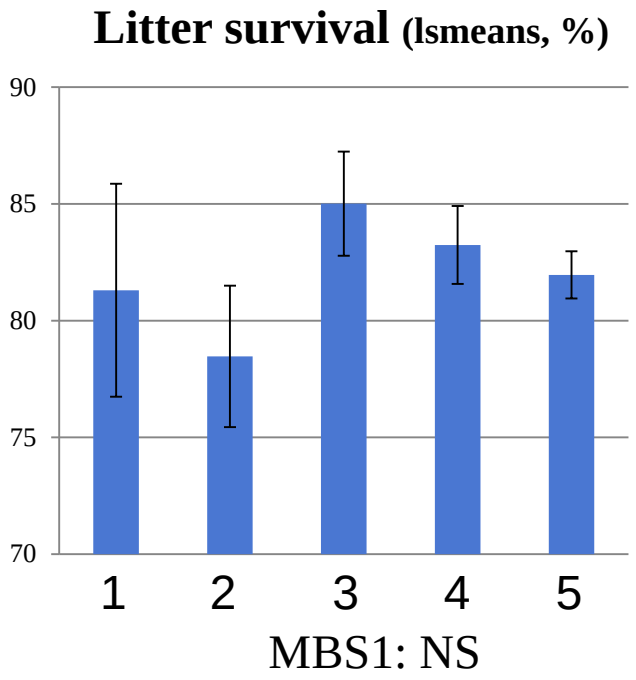
Arena test

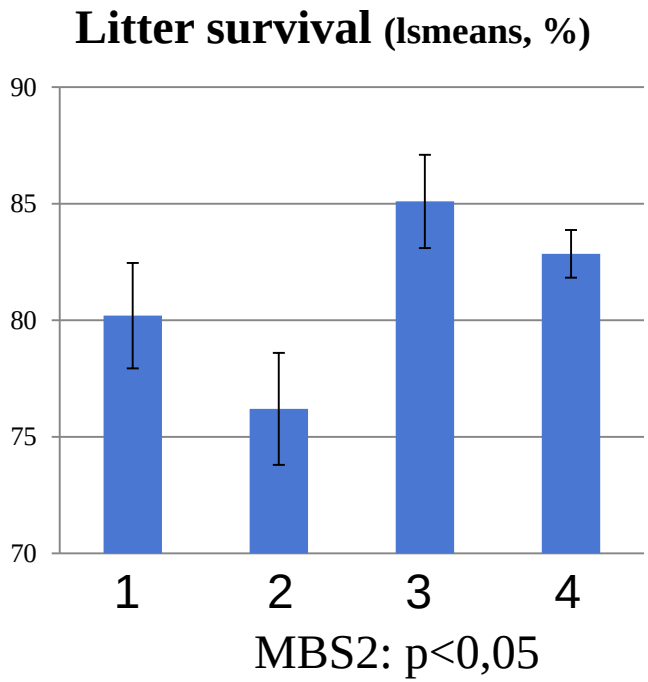
	LB (1)	HB (1)	HB (2/3)	Locom (2/3)	Prox (3)
LB(1)	0,44 +/- 0,05	-0,74 +/- 0,05	-0,24 +/- 0,10	NS	-0,29 +/- 0,12
HB(1)		0,44 +/- 0,05	0,70 +/- 0,07	NS	NS
HB(2/3)			0,46 +/- 0,05	NS	0,30 +/- 0,12
Locom (2/3)				0,15 +/- 0,04	NS
Prox (3)					0,27 +/- 0,04
r	0,58 +/- 0,06		0,60 +/- 0,06	0,30 +/- 0,06	0,42 +/- 0,06

Diagonal: heritability; r, repeatability

Results

Relationships with lamb mortality



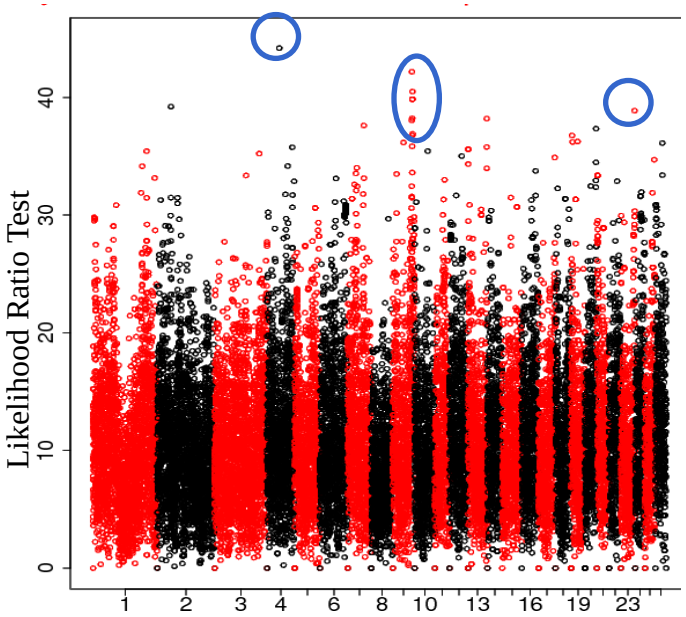


➢ **Litter survival increased as MBS increased.**

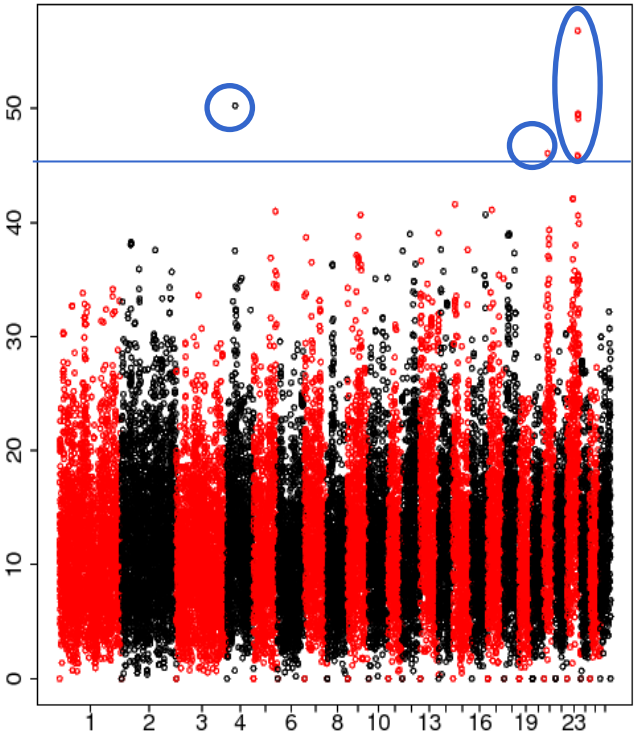
Results QTL mapping

Trait	OAR
MBS1	4, 9
MBS2	4, 9, 23
LB(1)	4, 21, 23
HB(1)	16, 21,23
HB(2/3)	4, 16
Locom(2/3)	1,11,19
Prox (3)	1, 5, 18

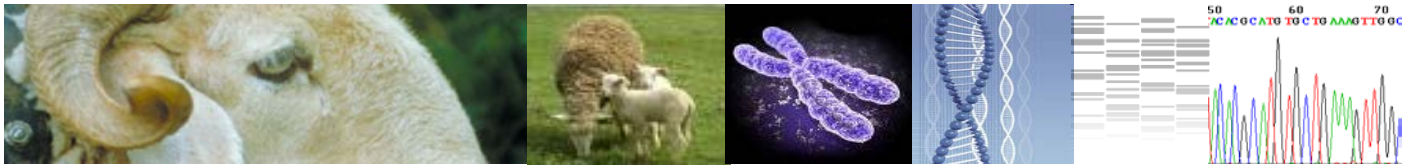
MBS2



Low bleat (Arena test 1)



Conclusion



Conclusion

Analytical issue:

- Several moderate to highly heritable traits associated with maternal reactivity for litter
- Several significant QTL associated with maternal reactivity

These results will:

- lead to a better knowledge of genetic variability of maternal behaviour in sheep
- help to understand behavioural interaction between ewe and lamb

Applied issue: This work presents a relevant approach that could be used to improve maternal behaviour of the ewes by genetic selection and to increase lamb survival

Perspectives: Further work required

- to investigate relationship between handling test and arena test

- to dissect underlying genetic mechanisms (to perform multitraits QTL analyses, to search candidate genes ...)

Acknowledgements

Mace T.[1], Kempeneers A.[1], Carriere F.[2], Douls S.[2], Foulquié D.[2], Delval E.[3], Boissy A.[3]

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- **ANR agency** for funding genotypes
- **INRA** for funding phenotypes


Thank you for your attention !