GENOME-WIDE STUDY FINDS A QTL WITH PLEOTROPIC EFFECT ON SEMEN AND PRODUCTION TRAITS IN SAANEN GOATS

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

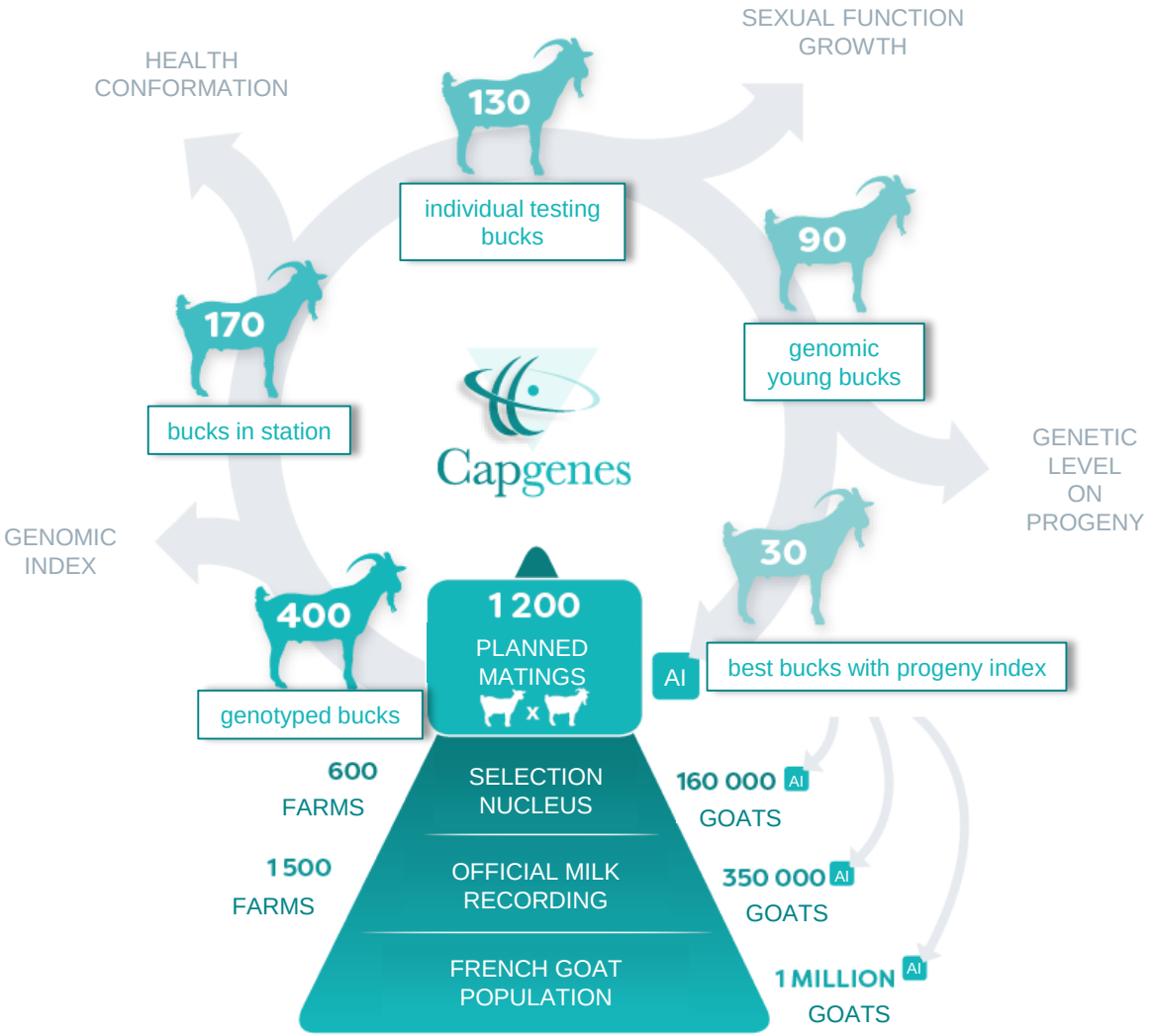
MINISTERE
DE L'AGRICULTURE
DE L'AGROALIMENTAIRE
ET DE LA FORET

avec la contribution financière du compte d'affectation spéciale «Développement agricole et rural»

Source : http://dico-sciences-animales.cirad.fr

C. Oget[1], V. Clément[2], I. Palhière[1], G. Tosser-Klopp[1], S. Fabre[1] & R. Rupp[1]
[1] GenPhySE, Université de Toulouse, INRA, INPT, ENVT, Castanet Tolosan, France
[2] Institut de l'Elevage, Castanet Tolosan, France

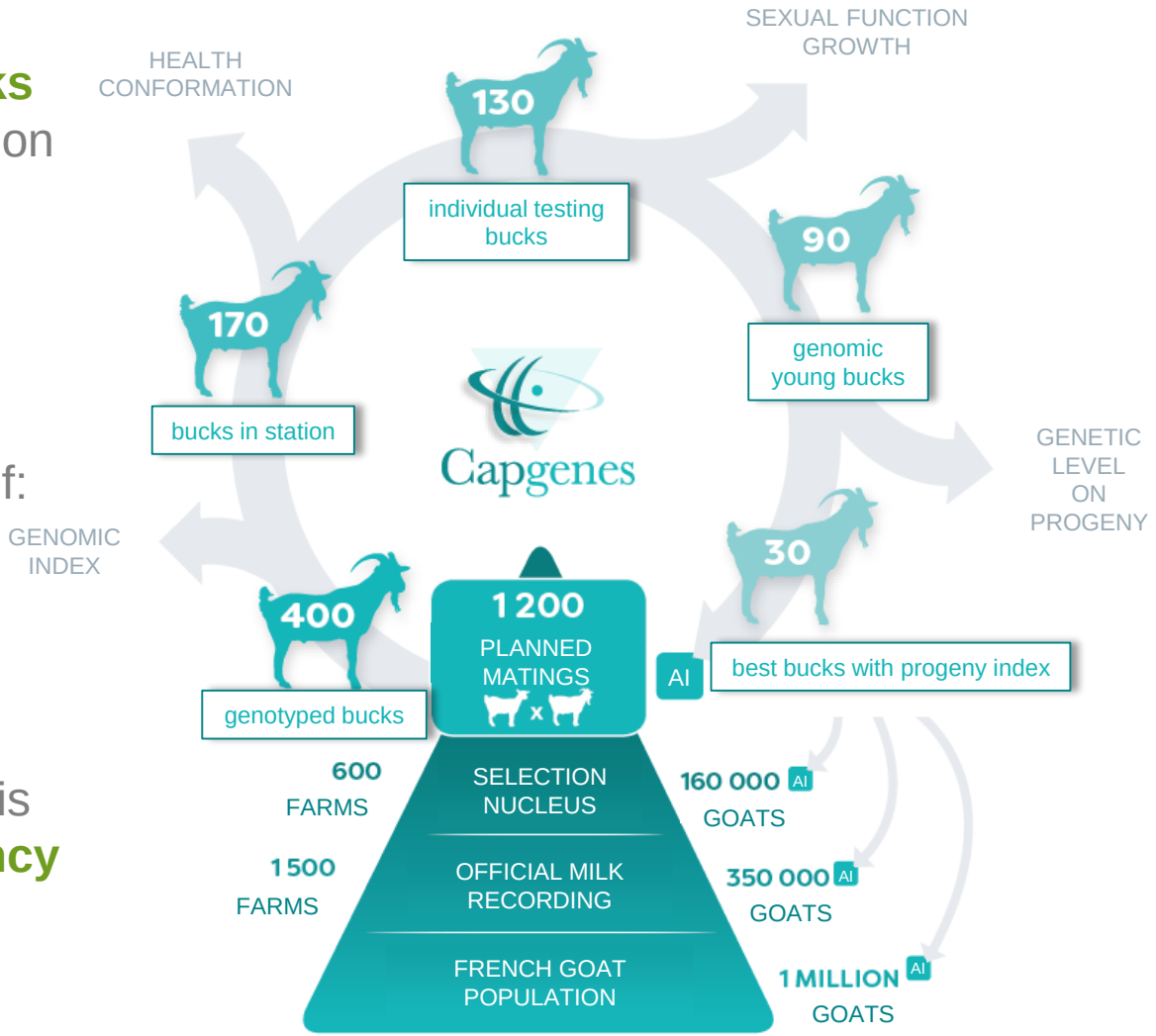
Background



FRENCH DAIRY GOAT SELECTION SCHEME IN 2018 (CAPGENES)

Background

- In France, **major role** of **bucks** from performance testing station in **selection efficiency and costs**
- Large number of bucks **eliminated before progeny testing** (47%) due to issues of:
  - Health
  - Conformation
  - Behaviour
  - **Semen quality**
- How can genetic impact on this major issue to ensure **efficiency of selection scheme** ?



FRENCH DAIRY GOAT SELECTION SCHEME IN 2018 (CAPGENES)

Source : http://chevrerielaramaz.over-blog.com

_01

MATERIALS & METHODS

Animals and phenotypes

Animals and phenotypes

Source : https://www.independent.co.uk

MALE TRAITS

5 **reproduction traits**:

- Semen **concentration**
- Semen **volume**
- **Number** of spermatozoa
- Percentage of **living spermatozoa** after thawing
- Spermatozoa **motility** after thawing

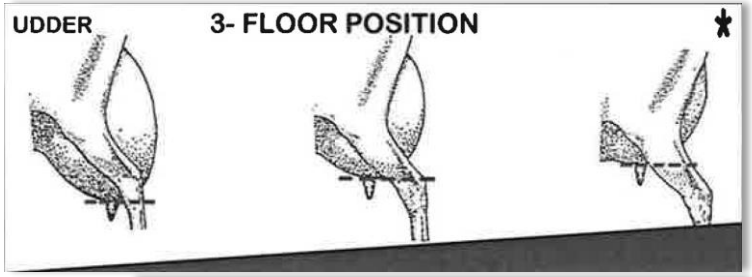
Animals and phenotypes

Source : https://www.independent.co.uk

MALE TRAITS

5 **reproduction traits**:

- Semen **concentration**
- Semen **volume**
- **Number** of spermatozoa
- Percentage of **living spermatozoa** after thawing
- Spermatozoa **motility** after thawing



Source : Capgenes

FEMALE TRAITS

- 11 **udder type** and **body condition** traits
- 5 **milk production** traits
- **Lifespan** of livestock
- Somatic Cell Score (SCS), **related to health**

Animals and phenotypes

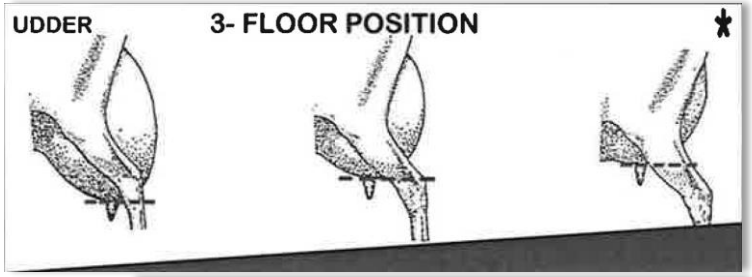
Source : https://www.independent.co.uk

MALE TRAITS

Bucks in performance testing stations genotyped with the **50K SNPs Goat Chip**

5 **reproduction traits**:

- Semen **concentration**
- Semen **volume**
- **Number** of spermatozoa
- Percentage of **living spermatozoa** after thawing
- Spermatozoa **motility** after thawing



Source : Capgenes

FEMALE TRAITS

- 11 **udder type** and **body condition** traits
- 5 **milk production** traits
- **Lifespan** of livestock
- Somatic Cell Score (SCS), **related to health**

Computing phenotypes for bucks

- Male **reproduction traits:**
  - **Repeated data** (from 1 to 447 repetitions / buck): Yield Deviations (**YD**)
  - **Corrected for environmental effects**: age, month and year of sampling, duration between sampling
  - Phenotypes used in the analyses: **mean of corrected data** for each individual

- Female **production traits** and **SCS:**
  - **Repeated data** (number of female lactations)
  - **Daughter Yield Deviations** (**DYD**) from official genetic evaluation
  - Average performance of daughters corrected for environmental effects and genetic value of their dam

Genome Wide Association Study (GWAS)

- **Linear mixed model**, with **genomic** kinship matrix
- **Single SNP tests** using **GEMMA** software (Zhou and Stephens, 2012)
- **Correction** for multiple tests: **Bonferroni** threshold
- Bucks in performance testing stations **genotyped** with the **50K SNPs Goat Chip** (Tosser-Klopp *et al.*, 2014)

	With male reproduction traits	With Female production traits and SCS
Alpine	672	597
Saanen	519	460

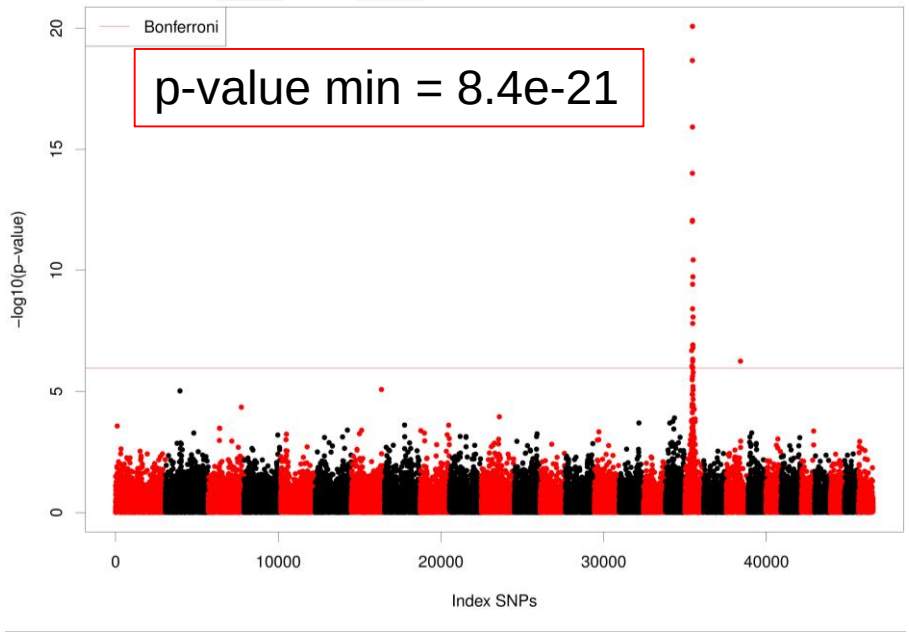
Source : https://www.independent.co.uk

_02

RESULTS & DISCUSSION

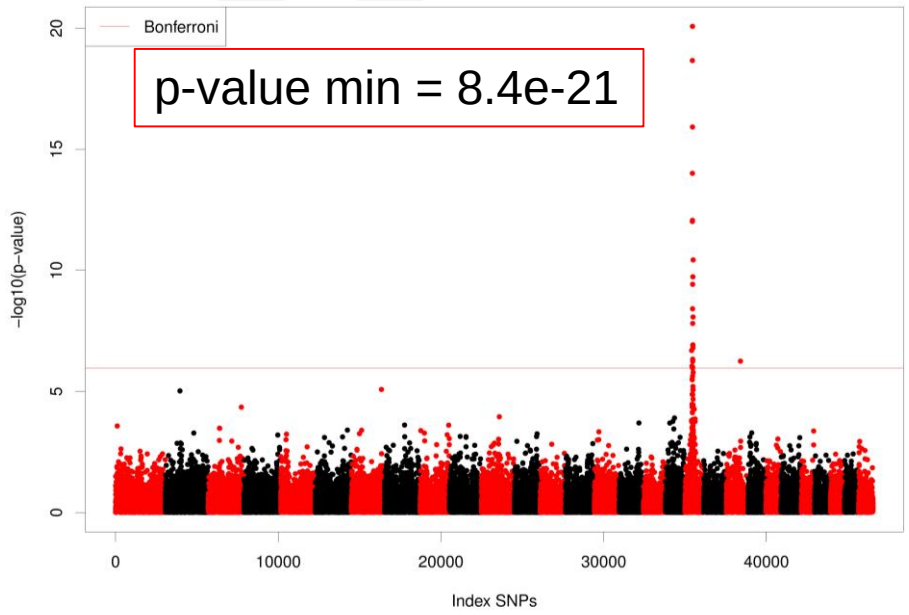
Discovery of a QTL (Quantitative Trait Loci) for semen production in the Saanen breed

Discovery of a QTL (Quantitative Trait Loci) for semen production in the Saanen breed



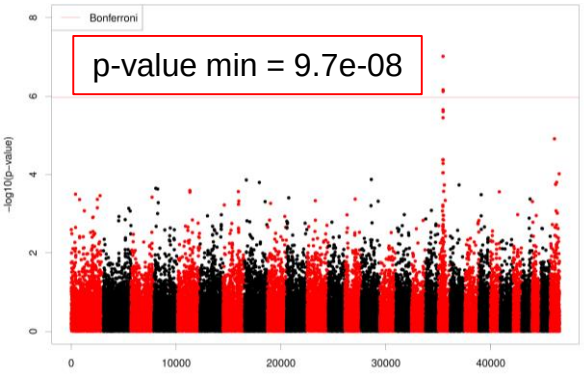
Manhattan plot: Semen volume

Discovery of a QTL (Quantitative Trait Loci) for semen production in the Saanen breed

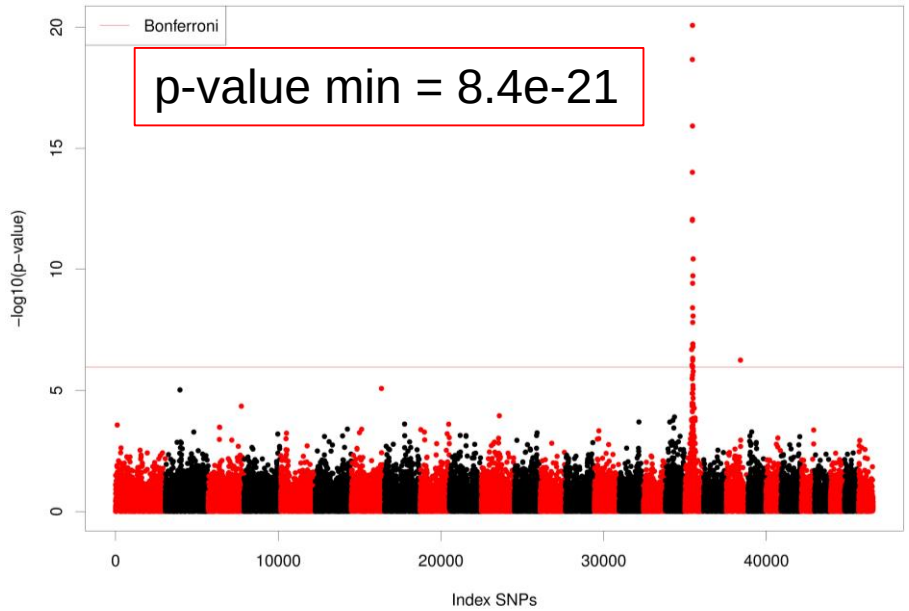


Manhattan plot: Semen volume

Semen concentration

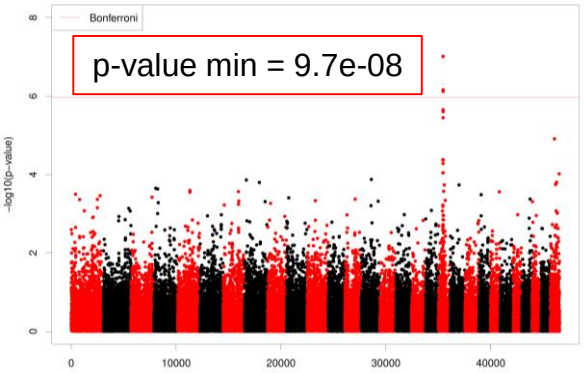


Discovery of a QTL (Quantitative Trait Loci) for semen production in the Saanen breed

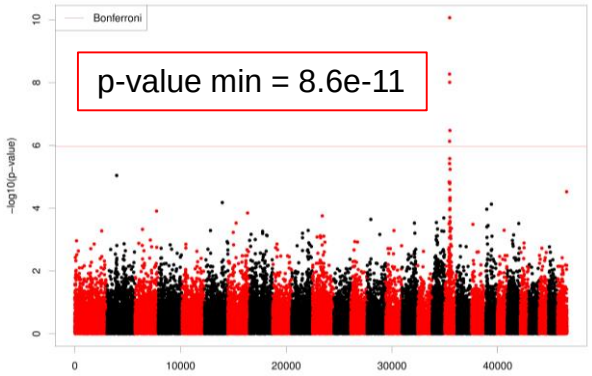


Manhattan plot: Semen volume

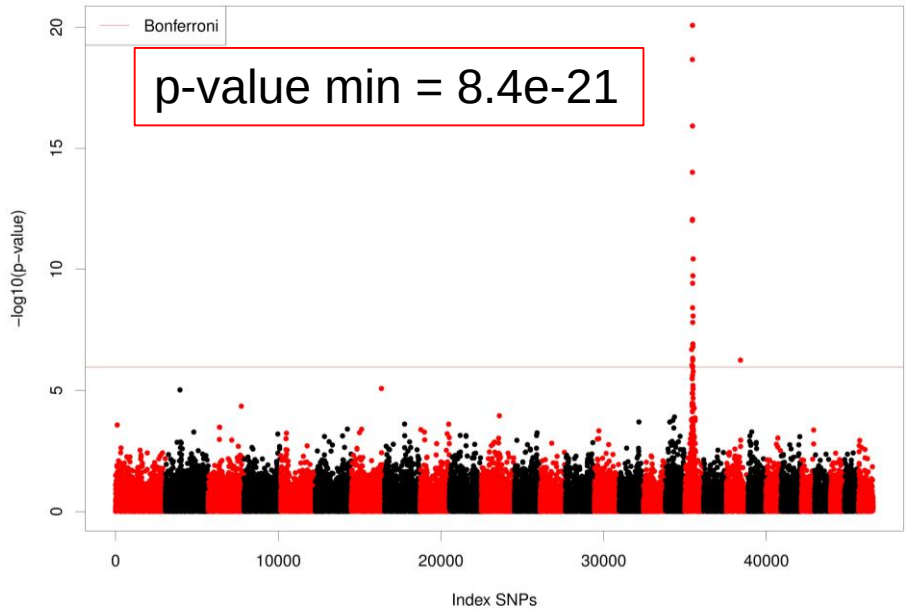
Semen concentration



Number of spermatozoa

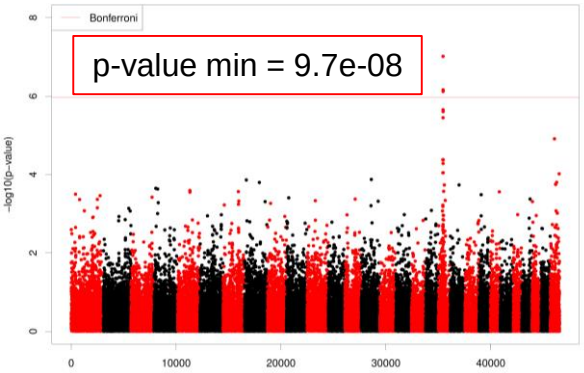


Discovery of a QTL (Quantitative Trait Loci) for semen production in the Saanen breed

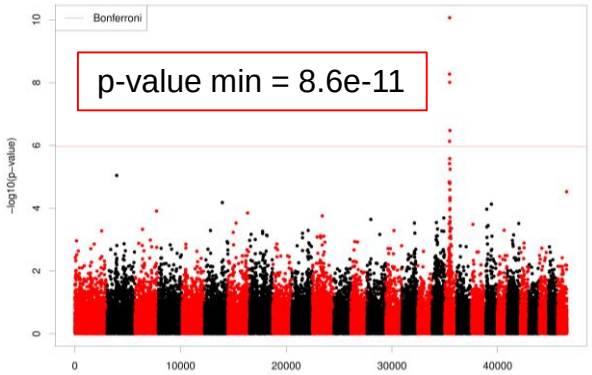


Manhattan plot: Semen volume

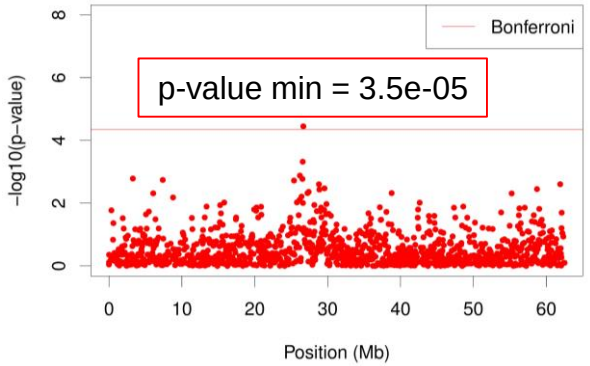
Semen concentration



Number of spermatozoa

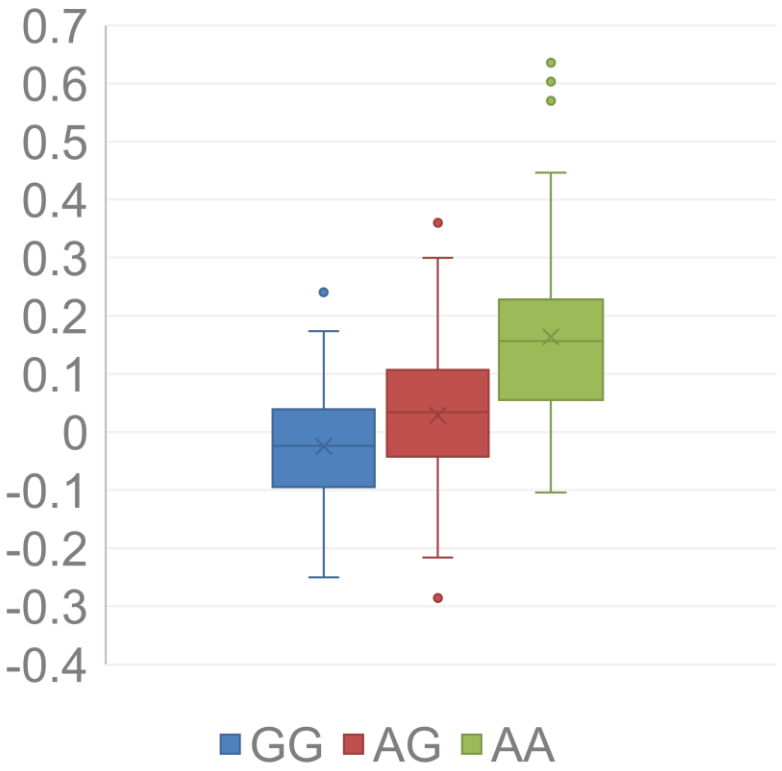


Percentage of living spermatozoa after thawing (CHR19 level)



One significant SNP effect on semen production

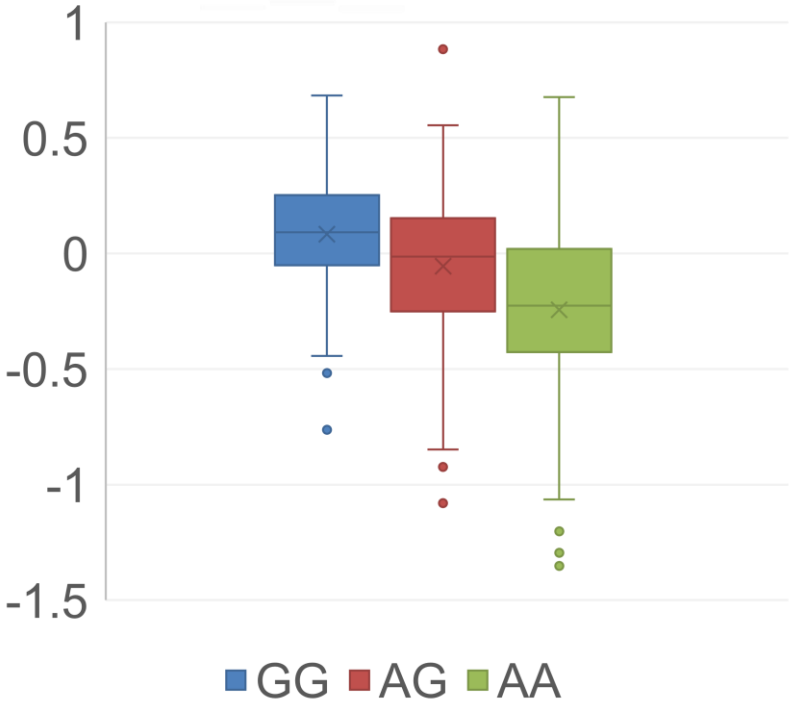
DYD for semen volume
according to the most significant SNP genotype



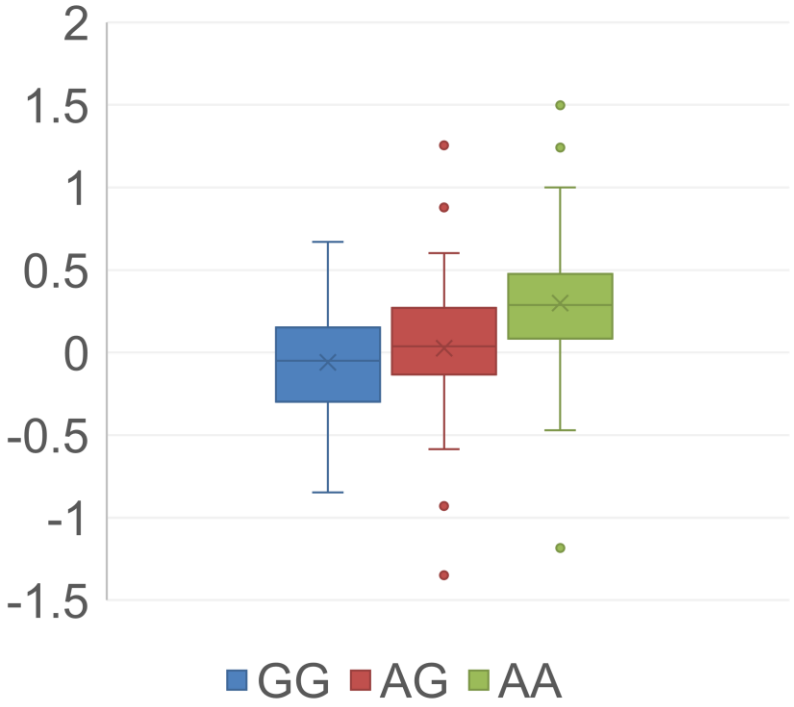
- ANOVA highly significant
- **The most significant SNP has an additive effect on semen volume**
- An individual carrying the A allele has a higher semen volume
- In Saanen, the frequency of this allele is close to 50%
- In Alpine, the frequency is less than 2% → lower semen volume

One significant SNP effect on semen production

DYD for semen concentration



DYD for number of spermatozoa



- An individual carrying the A allele has a lower semen concentration but a higher number of spermatozoa

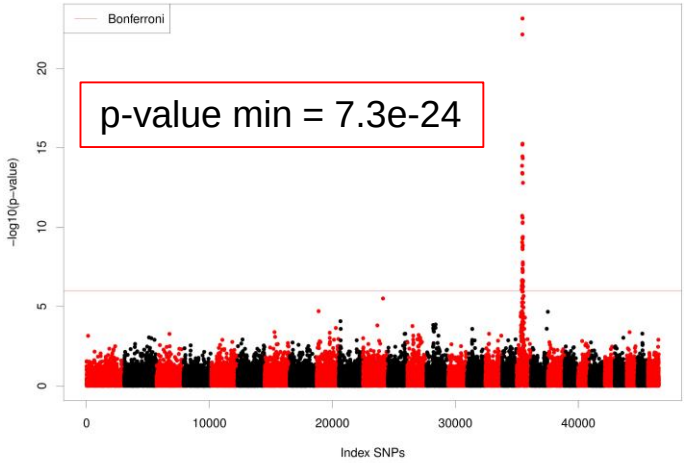
The QTL also associated with production traits in the Saanen breed

- **QTL for 14 of the 23** studied traits within all categories:
  - All the reproduction traits
  - Udder type traits: udder rear attachment, udder front, udder floor position, chest size
  - Milk production traits: milk, fat and protein yields
  - Lifespan of livestock
  - Trait related to health: SCS

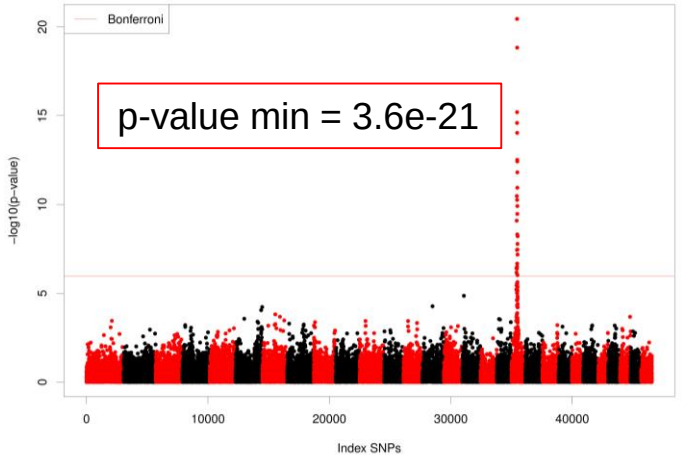
- These results confirm the **adverse pleiotropic QTL region for milk production and udder traits** found by Martin et al. (2018)

- We did not find this QTL in the **Alpine breed** suggesting a **breed-specific control**

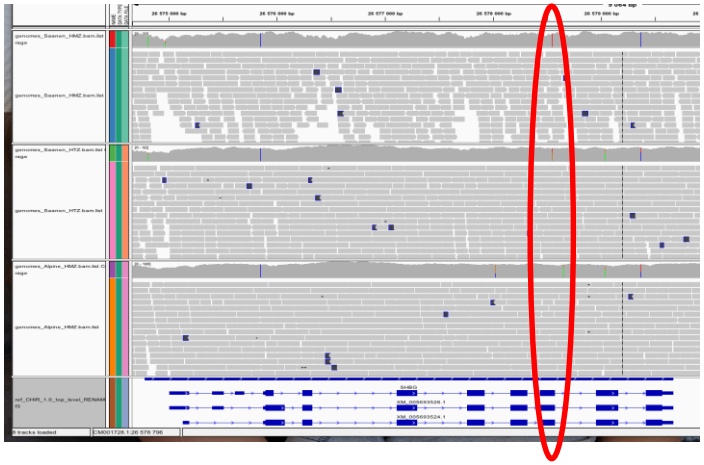
Udder floor position



Milk yield



Fine mapping of the QTL on CHR19 using sequence data



- In the **Saanen breed**:
  - Significant region on **chromosome 19**
  - **238 candidate genes**
  - Highest p-values position ≈ **26.61 Mb**

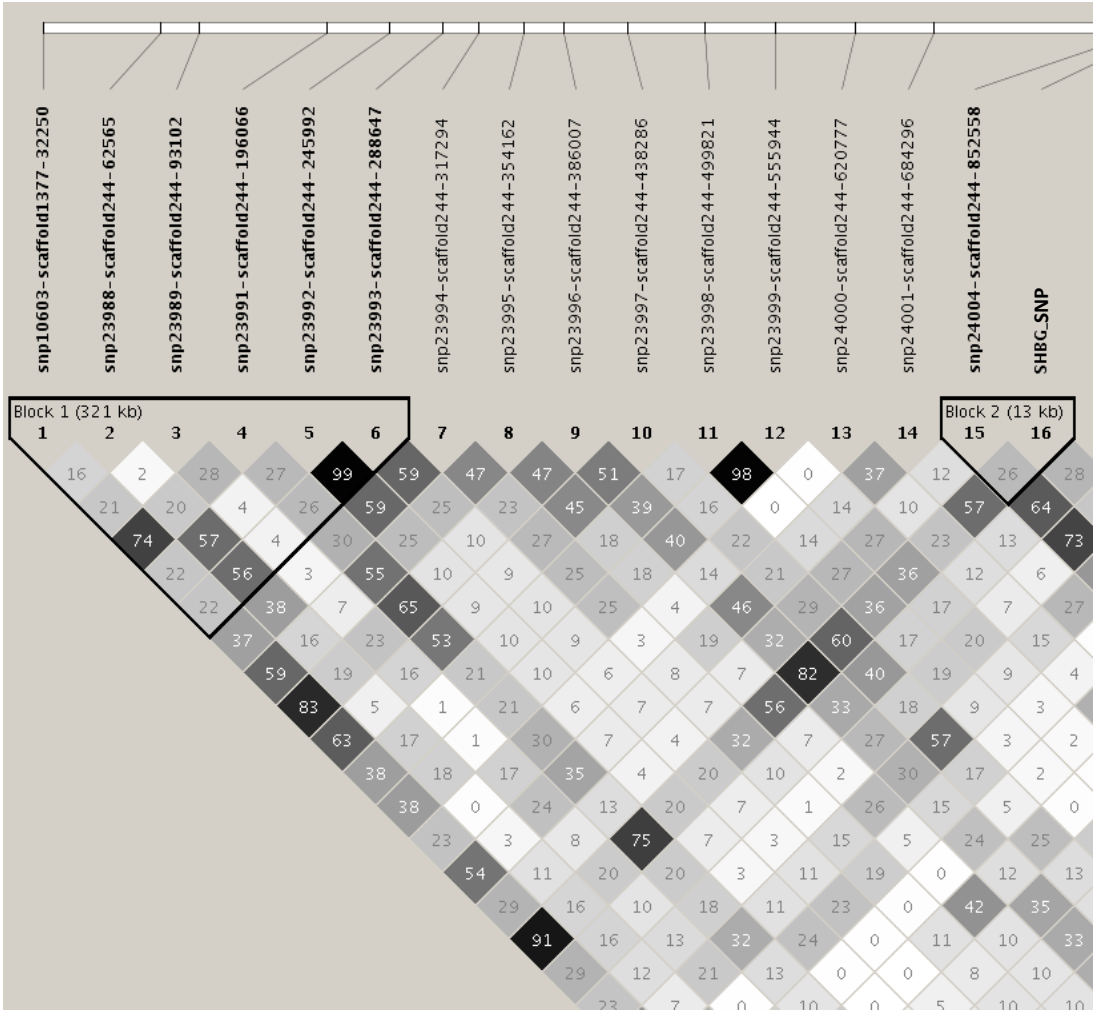
- **20 sequenced bucks**:
  - Search for **differences of allele frequencies** between the Alpine and Saanen sequences in the significant region
  - Aim: to find a mutation in the Saanen population at the origin of the strong association of this region with several male reproductive traits

- A **candidate mutation found in the SHBG gene** (Sex Hormone Binding Globulin)
  - An exonic SNP that modifies the amino acid sequence
  - Functions of SHBG: androgen transport protein, but may also be involved in steroid receptor mediated processes

The SHBG mutation closely linked to significants SNPs

- **SHBG_SNP genotyped** for 342 Saanen bucks
- Closely linked to the both most significant SNPs of the CHI 19 region in the GWAS

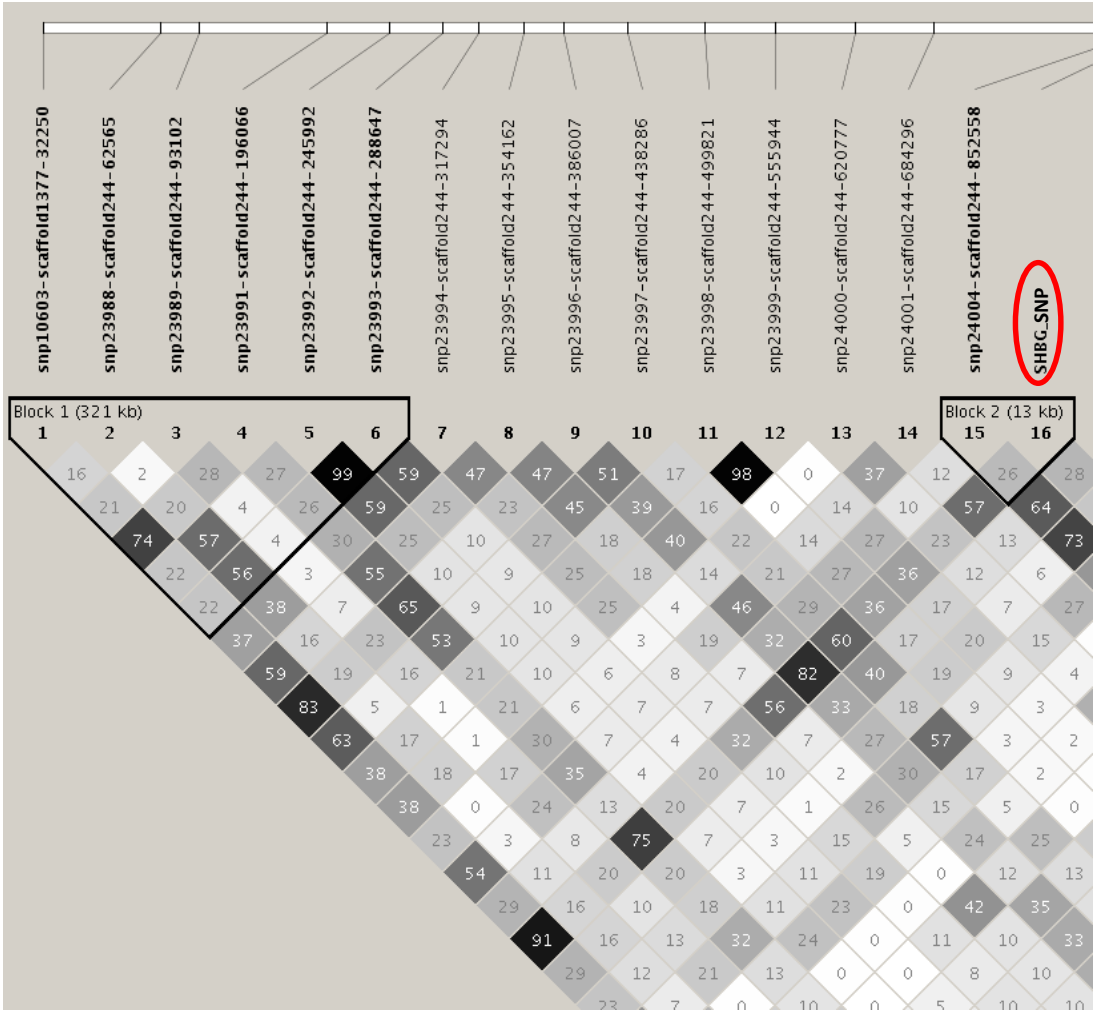
Linkage Disequilibrium = r^2 x100



The SHBG mutation closely linked to significants SNPs

- **SHBG_SNP genotyped** for 342 Saanen bucks
- Closely linked to the both most significant SNPs of the CHI 19 region in the GWAS

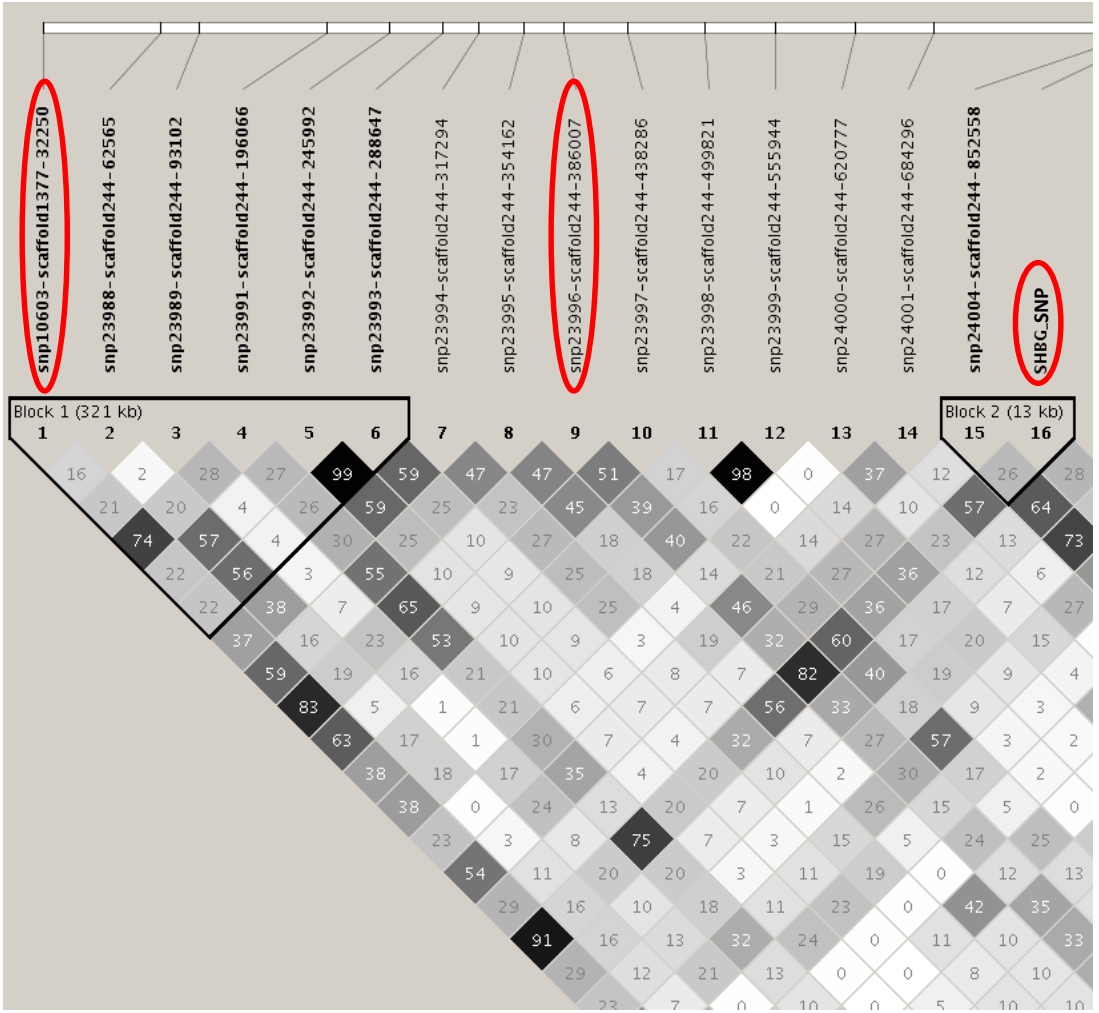
Linkage Disequilibrium = r^2 x100



The SHBG mutation closely linked to significants SNPs

- **SHBG_SNP genotyped** for 342 Saanen bucks
- Closely linked to the both most significant SNPs of the CHI 19 region in the GWAS

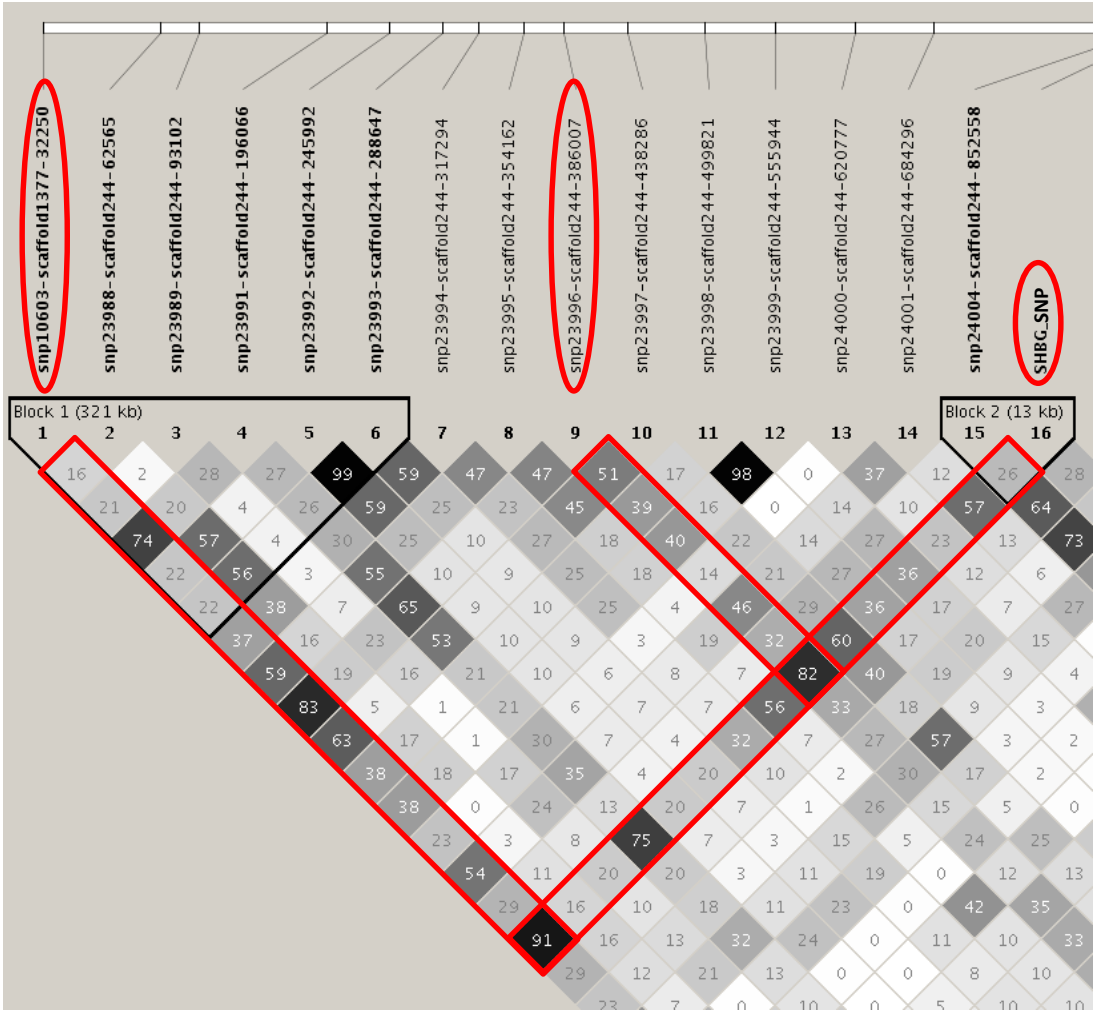
Linkage Disequilibrium = r^2 x100



The SHBG mutation closely linked to significants SNPs

- **SHBG_SNP genotyped** for 342 Saanen bucks
- Closely linked to the both most significant SNPs of the CHI 19 region in the GWAS

Linkage Disequilibrium = r^2 x100



TAKE HOME MESSAGE

- **Highly significant QTL** on chromosome 19 (22.8 - 28.9 Mb) in the **Saanen breed** for **semen production** and production traits

- The mutation has a favorable **additive effect on semen production** and is also linked to production traits (favorable effect for milk production) and adversely to udder traits (unfavorable effect for SCS and type traits)

- Candidate causal mutation in the Sex Hormone Binding Globulin (SHBG) gene

Thank you for your attention !

Any questions ?

Source : http://www.chevrotin-aop.fr

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
MINISTERE DE L'AGRICULTURE DE L'AGROALIMENTAIRE ET DE LA FORET
avec la contribution financière du compte d'affectation spéciale «Développement agricole et rural»