

# From womb to bloom

conception, early life and maternal effects on  
boar semen production

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EAAP

European Federation of Animal Science



# GERONIMO

Genome and Epigenome eNabled breeding in  
MONogastrics



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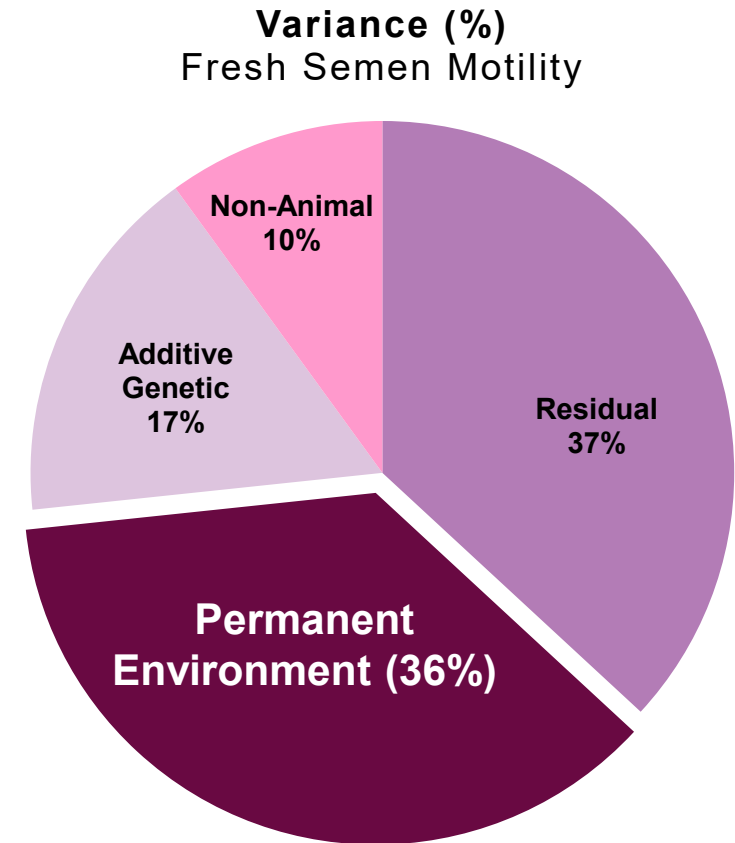


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# Variation in boar semen traits

- Boar **semen traits** have moderate heritability and **high repeatability**.
- **Permanent environment** is an effect intrinsic to the boar that may **describe early life** experiences.

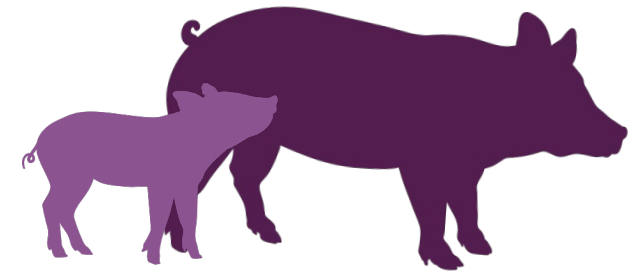
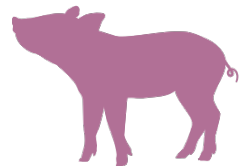
**What is the source?**

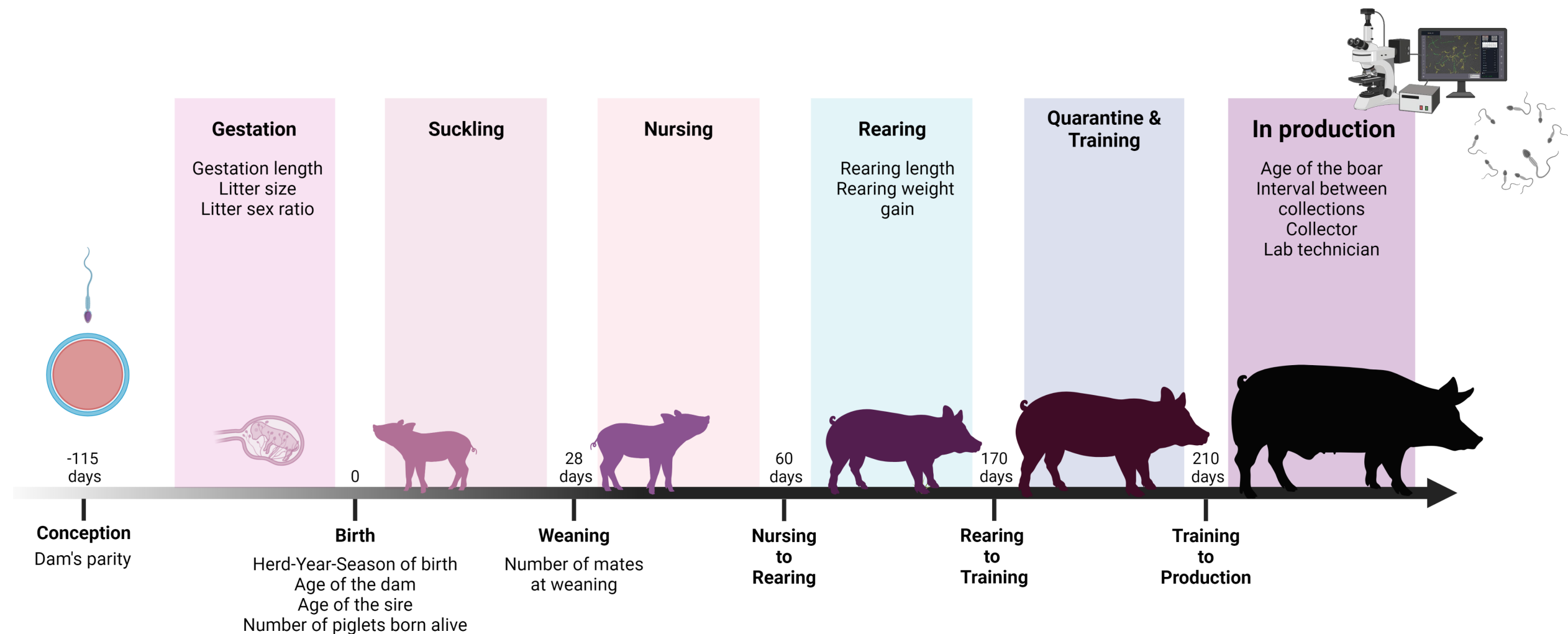


Broekhuijse, M. L., Godinho, R. M., & Knol, E. F. (2019). doi:10.1016/j.theriogenology.2019.05.069

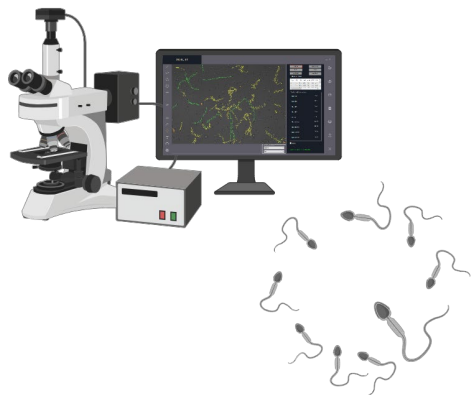
# Aim

**Do early life experiences and maternal conditions influence semen production of AI boars?**





# Phenotypes and models



## CASA evaluation

5,692 boars  
449,966 ejaculates

16 semen traits on fresh semen  
6 traits on stored semen

- *Semen quantity*
- *Sperm morphology*
- *Sperm motility*

## Model effects

- Effects at collection (e.g., age of the boar, collection interval, collector, etc.)
- Early-life effect (dam's parity, litter size, age of sire, etc.)
- Effect of herd-year-season of birth of the boar
- Permanent environmental effect (repeatability model)
- Genetic effect of the boar – using pedigree data (n=17,701)

# Significance

**Suggestive effect (\*)**  
p-value < 0.05

**Significant effect (\*\*)**  
p-value <  $2.3 \times 10^{-4}$

## Model effects

- Effects at collection (e.g., age of the boar, collection interval, collector, etc.)
- Early-life effect (dam's parity, litter size, age of sire, etc.)
- Effect of herd-year-season of birth of the boar
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# Significance of early-life conditions

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## Trait

### Semen Quantity

Volume (mL)

Concentration ( $10^6/\text{mL}$ )

### Sperm motility (%)

Total motility of fresh semen

Total motility after 2 days of storage

Total motility after 3 days of storage

Progressive motility after 1 days of storage

Progressive motility after 2 days of storage

Progressive motility after 3 days of storage

### Sperm Morphology (%)

Total morphological abnormalities

Total cytoplasmatic droplets

Proximal cytoplasmatic droplets

Distal cytoplasmatic droplets

Distal Midpiece Reflex

Abnormal Acrosome

# Significance of early-life conditions

| Trait                                        | Age Dam | Age Sire |
|----------------------------------------------|---------|----------|
| <b>Semen Quantity</b>                        |         |          |
| Volume (mL)                                  | -       | *        |
| Concentration (10 <sup>6</sup> /mL)          | -       | *        |
| <b>Sperm motility (%)</b>                    |         |          |
| Total motility of fresh semen                | -       | -        |
| Total motility after 2 days of storage       | -       | -        |
| Total motility after 3 days of storage       | -       | -        |
| Progressive motility after 1 days of storage | -       | -        |
| Progressive motility after 2 days of storage | -       | -        |
| Progressive motility after 3 days of storage | -       | -        |
| <b>Sperm Morphology (%)</b>                  |         |          |
| Total morphological abnormalities            | -       | -        |
| Total cytoplasmatic droplets                 | *       | -        |
| Proximal cytoplasmatic droplets              | *       | -        |
| Distal cytoplasmatic droplets                | *       | -        |
| Distal Midpiece Reflex                       | -       | -        |
| Abnormal Acrosome                            | -       | -        |

# Significance of early-life conditions

| Trait                                        | Age Dam | Age Sire | Dam parity | Gestation length | Litter size | Litter sex ratio |
|----------------------------------------------|---------|----------|------------|------------------|-------------|------------------|
| <b>Semen Quantity</b>                        |         |          |            |                  |             |                  |
| Volume (mL)                                  | -       | *        | -          | -                | -           | -                |
| Concentration (10 <sup>6</sup> /mL)          | -       | *        | -          | -                | -           | -                |
| <b>Sperm motility (%)</b>                    |         |          |            |                  |             |                  |
| Total motility of fresh semen                | -       | -        | -          | -                | -           | -                |
| Total motility after 2 days of storage       | -       | -        | -          | -                | -           | -                |
| Total motility after 3 days of storage       | -       | -        | -          | -                | *           | -                |
| Progressive motility after 1 days of storage | -       | -        | -          | *                | -           | -                |
| Progressive motility after 2 days of storage | -       | -        | -          | -                | -           | -                |
| Progressive motility after 3 days of storage | -       | -        | -          | -                | *           | -                |
| <b>Sperm Morphology (%)</b>                  |         |          |            |                  |             |                  |
| Total morphological abnormalities            | -       | -        | -          | -                | *           | -                |
| Total cytoplasmatic droplets                 | *       | -        | -          | -                | -           | -                |
| Proximal cytoplasmatic droplets              | *       | -        | -          | -                | -           | -                |
| Distal cytoplasmatic droplets                | *       | -        | -          | -                | -           | -                |
| Distal Midpiece Reflex                       | -       | -        | *          | -                | -           | -                |
| Abnormal Acrosome                            | -       | -        | -          | *                | -           | -                |

# Significance of early-life conditions

| Trait                                        | Age Dam | Age Sire | Dam parity | Gestation length | Litter size |
|----------------------------------------------|---------|----------|------------|------------------|-------------|
| <b>Semen Quantity</b>                        |         |          |            |                  |             |
| Volume (mL)                                  | -       | *        | -          | -                | -           |
| Concentration (10 <sup>6</sup> /mL)          | -       | *        | -          | -                | -           |
| <b>Sperm motility (%)</b>                    |         |          |            |                  |             |
| Total motility of fresh semen                | -       | -        | -          | -                | -           |
| Total motility after 2 days of storage       | -       | -        | -          | -                | -           |
| Total motility after 3 days of storage       | -       | -        | -          | -                | *           |
| Progressive motility after 1 days of storage | -       | -        | -          | *                | -           |
| Progressive motility after 2 days of storage | -       | -        | -          | -                | -           |
| Progressive motility after 3 days of storage | -       | -        | -          | -                | *           |
| <b>Sperm Morphology (%)</b>                  |         |          |            |                  |             |
| Total morphological abnormalities            | -       | -        | -          | -                | *           |
| Total cytoplasmatic droplets                 | *       | -        | -          | -                | -           |
| Proximal cytoplasmatic droplets              | *       | -        | -          | -                | -           |
| Distal cytoplasmatic droplets                | *       | -        | -          | -                | -           |
| Distal Midpiece Reflex                       | -       | -        | *          | -                | -           |
| Abnormal Acrosome                            | -       | -        | -          | *                | -           |

# Significance of early-life conditions

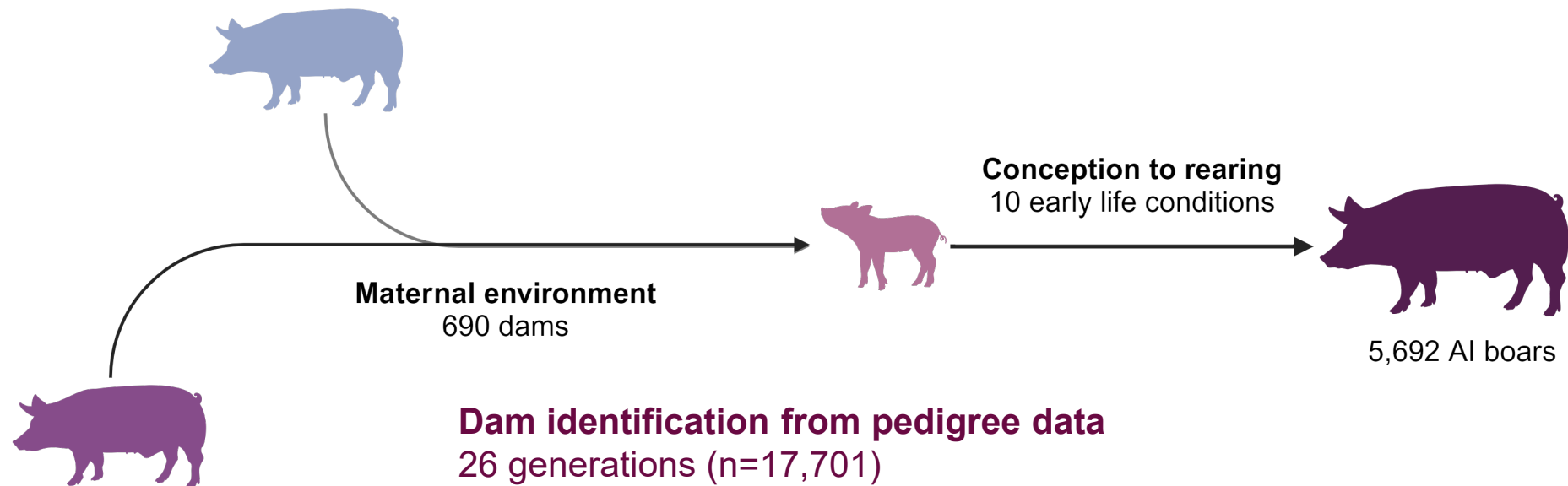
| Trait                                        | Age Dam | Age Sire | Dam parity | Gestation length | Litter size | Number of born alive | Number of mates at weaning |
|----------------------------------------------|---------|----------|------------|------------------|-------------|----------------------|----------------------------|
| <b>Semen Quantity</b>                        |         |          |            |                  |             |                      |                            |
| Volume (mL)                                  | -       | *        | -          | -                | -           | -                    | -                          |
| Concentration (10 <sup>6</sup> /mL)          | -       | *        | -          | -                | -           | -                    | -                          |
| <b>Sperm motility (%)</b>                    |         |          |            |                  |             |                      |                            |
| Total motility of fresh semen                | -       | -        | -          | -                | -           | -                    | -                          |
| Total motility after 2 days of storage       | -       | -        | -          | -                | -           | -                    | -                          |
| Total motility after 3 days of storage       | -       | -        | -          | -                | *           | -                    | -                          |
| Progressive motility after 1 days of storage | -       | -        | -          | *                | -           | -                    | -                          |
| Progressive motility after 2 days of storage | -       | -        | -          | -                | -           | -                    | -                          |
| Progressive motility after 3 days of storage | -       | -        | -          | -                | *           | -                    | -                          |
| <b>Sperm Morphology (%)</b>                  |         |          |            |                  |             |                      |                            |
| Total morphological abnormalities            | -       | -        | -          | -                | *           | -                    | -                          |
| Total cytoplasmatic droplets                 | *       | -        | -          | -                | -           | -                    | -                          |
| Proximal cytoplasmatic droplets              | *       | -        | -          | -                | -           | -                    | -                          |
| Distal cytoplasmatic droplets                | *       | -        | -          | -                | -           | *                    | -                          |
| Distal Midpiece Reflex                       | -       | -        | *          | -                | -           | *                    | -                          |
| Abnormal Acrosome                            | -       | -        | -          | *                | -           | -                    | -                          |

# Significance of early-life conditions

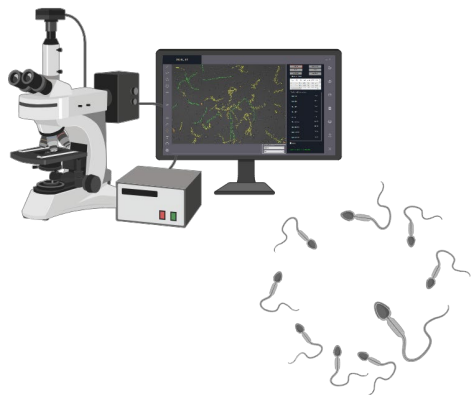
| Trait                                        | Age Dam | Age Sire | Dam parity | Gestation length | Litter size | Number of born alive |
|----------------------------------------------|---------|----------|------------|------------------|-------------|----------------------|
| <b>Semen Quantity</b>                        |         |          |            |                  |             |                      |
| Volume (mL)                                  | -       | *        | -          | -                | -           | -                    |
| Concentration (10 <sup>6</sup> /mL)          | -       | *        | -          | -                | -           | -                    |
| <b>Sperm motility (%)</b>                    |         |          |            |                  |             |                      |
| Total motility of fresh semen                | -       | -        | -          | -                | -           | -                    |
| Total motility after 2 days of storage       | -       | -        | -          | -                | -           | -                    |
| Total motility after 3 days of storage       | -       | -        | -          | -                | *           | -                    |
| Progressive motility after 1 days of storage | -       | -        | -          | *                | -           | -                    |
| Progressive motility after 2 days of storage | -       | -        | -          | -                | -           | -                    |
| Progressive motility after 3 days of storage | -       | -        | -          | -                | *           | -                    |
| <b>Sperm Morphology (%)</b>                  |         |          |            |                  |             |                      |
| Total morphological abnormalities            | -       | -        | -          | -                | *           | -                    |
| Total cytoplasmatic droplets                 | *       | -        | -          | -                | -           | -                    |
| Proximal cytoplasmatic droplets              | *       | -        | -          | -                | -           | -                    |
| Distal cytoplasmatic droplets                | *       | -        | -          | -                | -           | *                    |
| Distal Midpiece Reflex                       | -       | -        | *          | -                | -           | *                    |
| Abnormal Acrosome                            | -       | -        | -          | *                | -           | -                    |

# Significance of early-life conditions

| Trait                                        | Age Dam | Age Sire | Dam parity | Gestation length | Litter size | Number of born alive | Rearing length | Rearing weight growth |
|----------------------------------------------|---------|----------|------------|------------------|-------------|----------------------|----------------|-----------------------|
| <b>Semen Quantity</b>                        |         |          |            |                  |             |                      |                |                       |
| Volume (mL)                                  | -       | *        | -          | -                | -           | -                    | -              | -                     |
| Concentration (10 <sup>6</sup> /mL)          | -       | *        | -          | -                | -           | -                    | *              | -                     |
| <b>Sperm motility (%)</b>                    |         |          |            |                  |             |                      |                |                       |
| Total motility of fresh semen                | -       | -        | -          | -                | -           | -                    | *              | -                     |
| Total motility after 2 days of storage       | -       | -        | -          | -                | -           | -                    | *              | -                     |
| Total motility after 3 days of storage       | -       | -        | -          | -                | *           | -                    | -              | -                     |
| Progressive motility after 1 days of storage | -       | -        | -          | *                | -           | -                    | -              | -                     |
| Progressive motility after 2 days of storage | -       | -        | -          | -                | -           | -                    | *              | -                     |
| Progressive motility after 3 days of storage | -       | -        | -          | -                | *           | -                    | -              | -                     |
| <b>Sperm Morphology (%)</b>                  |         |          |            |                  |             |                      |                |                       |
| Total morphological abnormalities            | -       | -        | -          | -                | *           | -                    | -              | -                     |
| Total cytoplasmatic droplets                 | *       | -        | -          | -                | -           | -                    | -              | *                     |
| Proximal cytoplasmatic droplets              | *       | -        | -          | -                | -           | -                    | -              | -                     |
| Distal cytoplasmatic droplets                | *       | -        | -          | -                | -           | *                    | -              | *                     |
| Distal Midpiece Reflex                       | -       | -        | *          | -                | -           | *                    | *              | -                     |
| Abnormal Acrosome                            | -       | -        | -          | *                | -           | -                    | -              | -                     |



# Phenotypes and models



## CASA evaluation

**2,837 boars**  
230,655 ejaculates

16 semen traits on fresh semen  
2 traits on stored semen

- *Semen quantity*
- *Sperm morphology*
- *Sperm motility*

## Model effects

- Effects at collection (e.g., age of the boar, collection interval, collector, etc.)
- Effect of herd-year-season of birth of the boar
- Permanent environmental effect (repeatability model)
- Genetic effect of the boar – using pedigree data (n=17,701)
- **Maternal environment effect - Boar's dam of origin**

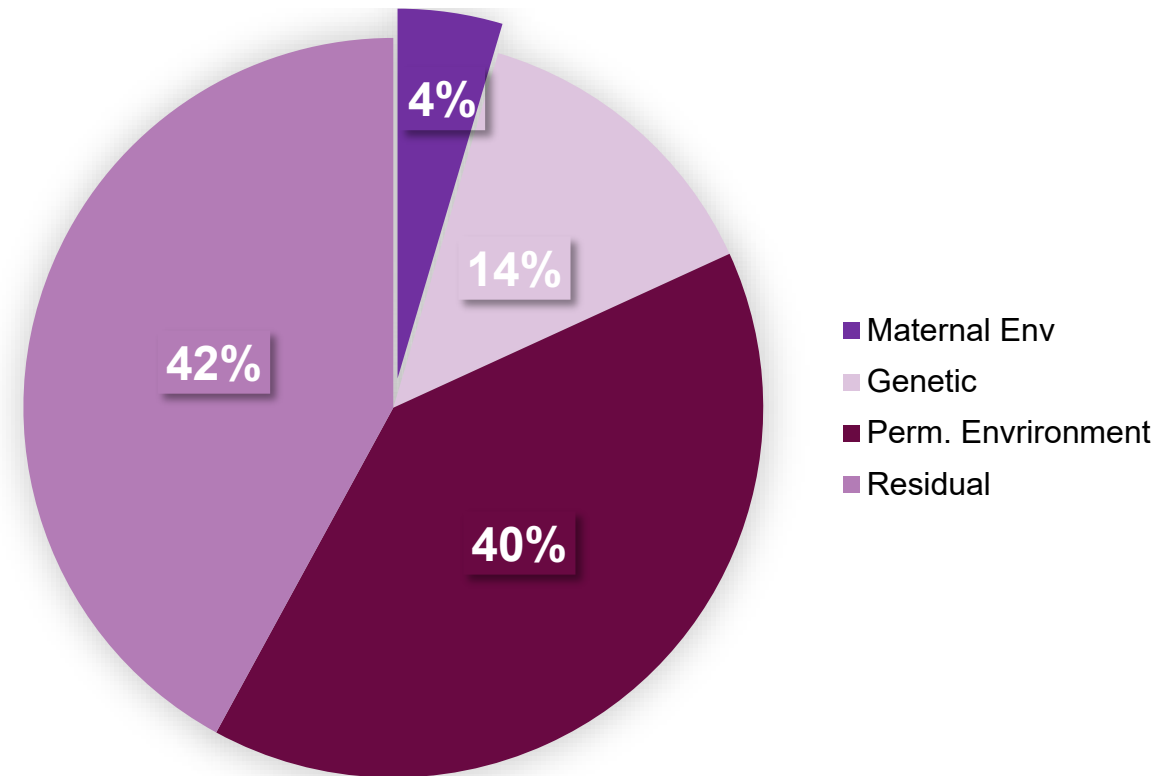
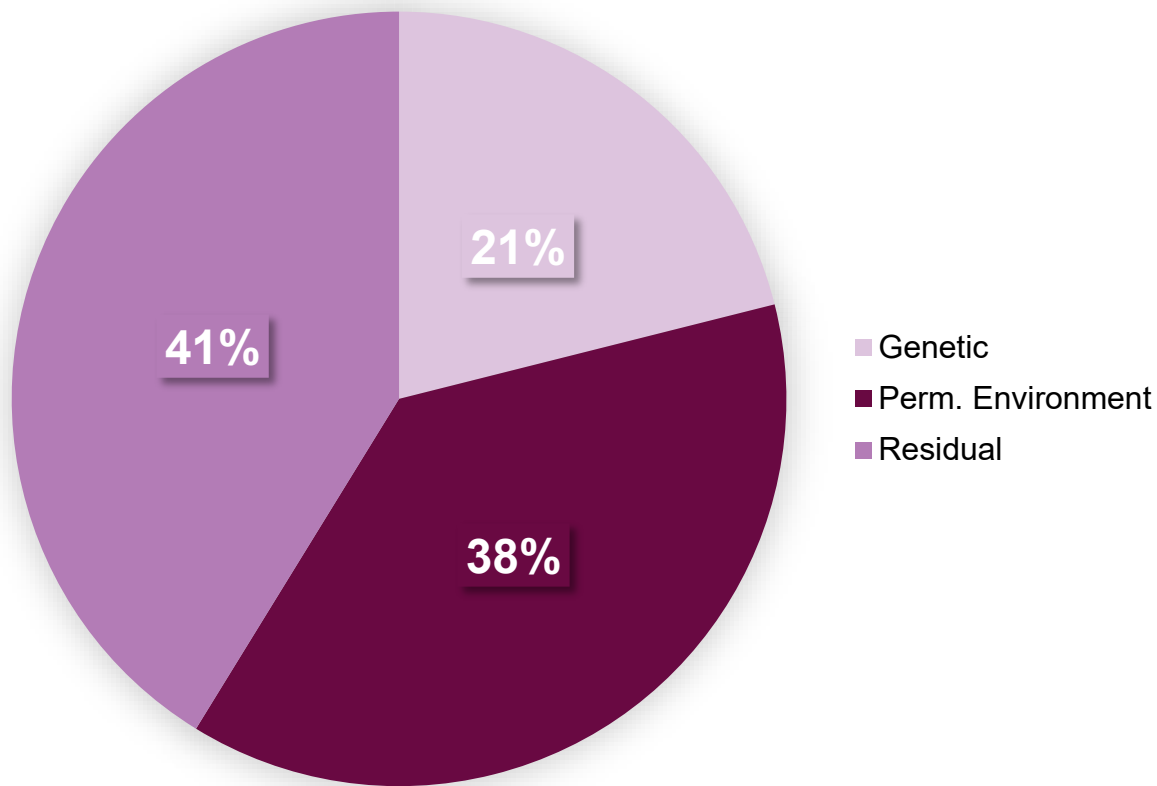
# Maternal environment influences offspring semen traits

Percentage of phenotypic variance explained by maternal environment effects, heritabilities and repeatabilities.

| Trait                                            | Maternal Environment variance, % | $h^2$         | $rep$ |
|--------------------------------------------------|----------------------------------|---------------|-------|
| Volume (mL)                                      | 1.5                              | 0.22 (↓ 0.01) | 0.37  |
| Total motility of fresh semen (%)                | 4.6                              | 0.14 (↓ 0.07) | 0.53  |
| Total motility after 3 days of storage (%)       | 2.5                              | 0.15 (↓ 0.07) | 0.37  |
| Progressive motility of fresh semen (%)          | 2.8                              | 0.16 (↓ 0.06) | 0.47  |
| Progressive motility after 3 days of storage (%) | 2.3                              | 0.15 (↓ 0.07) | 0.39  |
| Total morphological abnormalities (%)            | 3.1                              | 0.12 (↓ 0.07) | 0.49  |

# Maternal environment influences offspring semen traits

**Variance (%)**  
Total motility of fresh semen



# Discussion

**Early-life conditions of boars do not have significant effects on semen traits later in life.**

- Possibly due to relatively **uniform environmental conditions**.
- Boars that do not qualify for AI station during quarantine and training, lack semen records and introduces the possibility that their exclusion is linked to early-life conditions.

**Maternal environment influences boar semen traits.**

- The "Maternal environment effect" is a term in a statistical model that can **represent several effects**.
- Maternal environment effect may include housing and nutrition conditions of the dam during gestation and suckling.