

Early life nutrition advances sexual development and semen availability in the bull



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Why advance sexual development?

- **Generation interval limits genetic gain**
 - Generation interval = average age of the parents when offspring are born
- **Genomic selection**
- **Puberty and sexual maturation**
- **Semen production from peri-pubertal bulls**
 - Lower semen quantity and quality from peri-pubertal bulls (Murphy *et al.*, 2018)
 - 30-50% of semen yield of mature bull in first year at stud (Amann and DeJarnette, 2012)



Early life nutrition and sexual development in cattle

- Rate of sexual development and age at puberty onset affected by:
 - Breed
 - environmental influences i.e. season, nutrition,
- Likely mediated through complex neuroendocrine signalling
- Timing of nutritional intervention is likely important to the potency of the response (Harstine *et al.*, 2015, Byrne *et al.* 2018a)



Kenny and Byrne (2018). *Animal*. 12 (S1):36-44

Experiment

Effect of plane of nutrition (i) pre- and (ii) post-six months of age in Holstein-Friesian bulls, on age at puberty and post-pubertal semen production

Byrne *et al.* (2018). *J. Dairy Sci.* 101(4):3447-3459

Byrne *et al.* (2018). *J. Dairy Sci.* 101(4):3460-3475

Experimental design



Holstein-Friesian bull calves (n=82)

2 weeks

High
(n=37)

Low
(n=46)

24 weeks

High
(n=19)

Low
(n=18)

Low
(n=24)

High
(n=22)

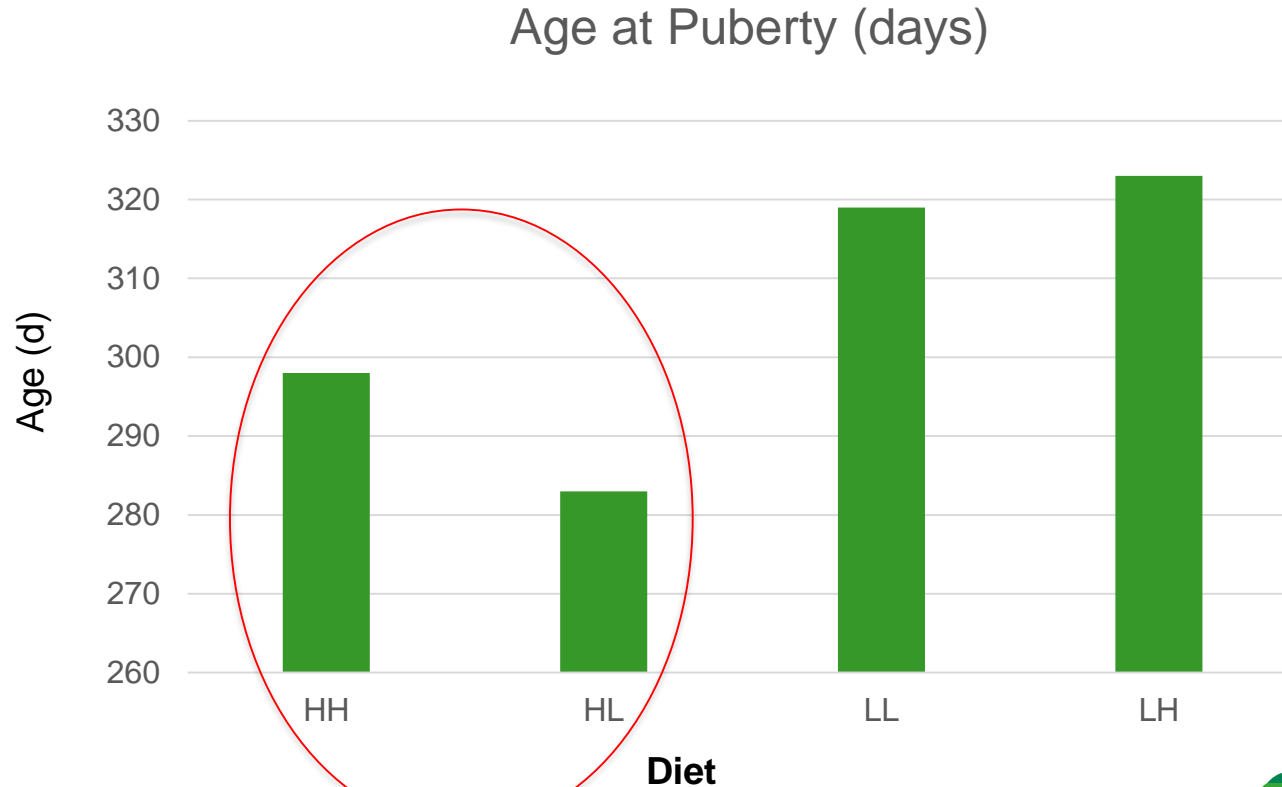
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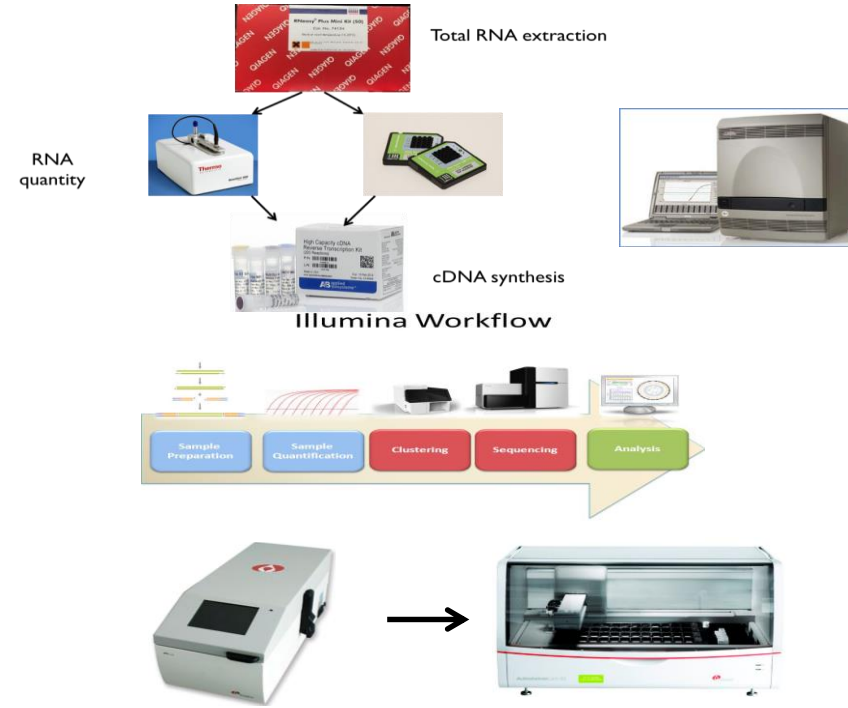
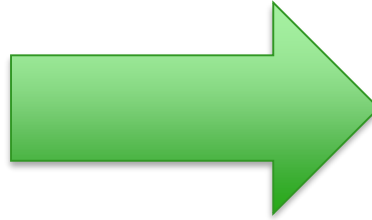
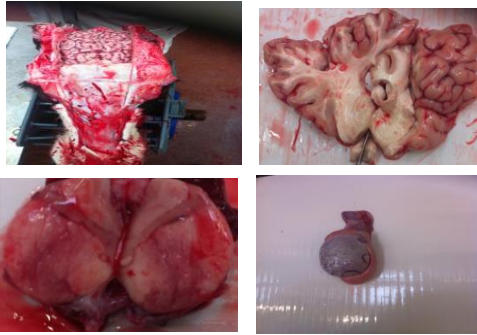
Effect of early life plane of nutrition on timing of puberty in Holstein-Friesian bulls



Byrne *et al.* (2018a)

Morphological and molecular analysis of the brain-testes axis

- Arcuate region of hypothalamus
- Anterior pituitary
- Testes
- Adipose & liver



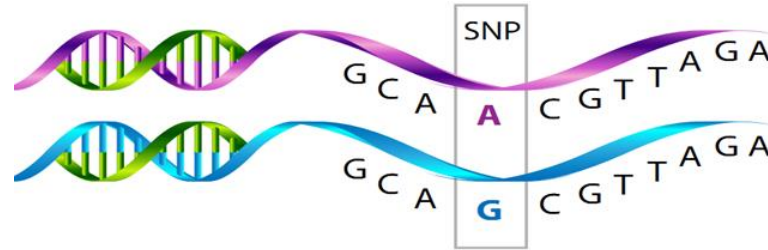
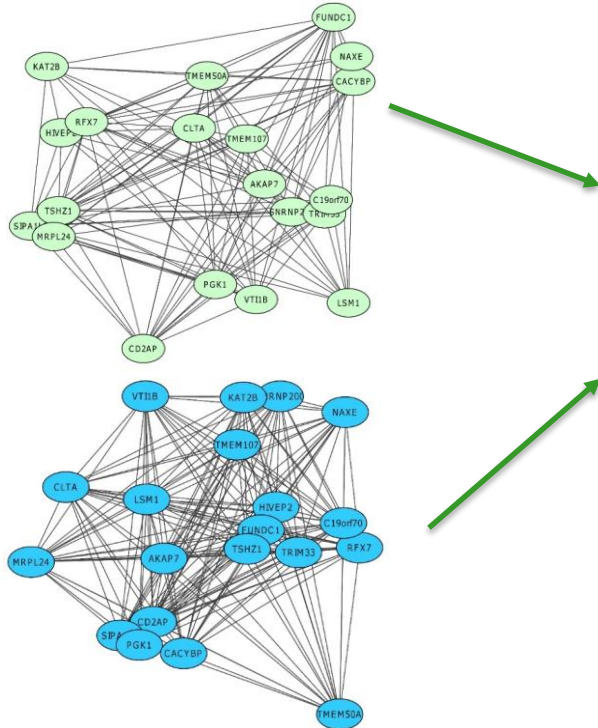
Analyses

- RT-PCR
- RNASeq
- Histology, IHC

English et al. (2018a,b,c)

Integrating 'omics' datasets

- Advanced bioinformatics and gene network analysis
- Identification of key genes and variants affecting fertility traits



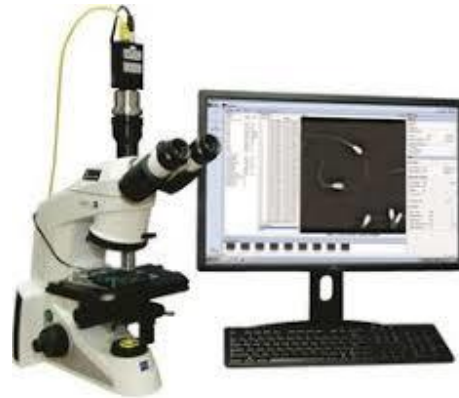
Semen characteristics and fertility

- Improved early life nutrition hastens onset of puberty and sexual maturity
- Latent effects on post-pubertal semen quality and fertility??



Semen Quality

- Collected semen monthly (8-17 mths of age)
- Bulls on H diet - earlier availability of semen with
 - Greater sperm concentration
 - Greater sperm motility



Post pubertal semen production

Effect of early pre-pubertal plane of nutrition on estimated number¹ and sale value² of semen straws per ejaculate from HF bulls aged 12 -15 months

| | High/High | High/Low | Low/High | Low/Low |
|----------------------|-----------|----------|----------|---------|
| Number of straws | 308 | 205 | 177 | 92 |
| Commercial value (€) | 4619 | 3073 | 2662 | 1377 |

¹15 million sperm/straw

²€15/straw



Byrne *et al.* (2018)

Post pubertal fertility - IVF

| Treatment | High/High | High/Low | Low/High | Low/Low |
|--------------------|-----------------|-----------------|-----------------|-----------------|
| Oocytes (n) | 924 | 1355 | 1345 | 1060 |
| % Cleaved | 75.0 ± 0.05 | 69.2 ± 0.04 | 75.5 ± 0.03 | 70.5 ± 0.05 |
| % Blastocysts (7d) | 28.6 ± 0.03 | 28.5 ± 0.03 | 31.8 ± 0.03 | 27.7 ± 0.02 |





Effect of feeding Plane of nutrition of Friesian age at



J. Dairy Sci. 101:1–16
<https://doi.org/10.3168/jds.2017-13720>

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BMC Genomics

Theriogenology 96 (2017) 58–68

Contents lists available at ScienceDirect



ELSE

Animal (2016), 10:9, pp 1547–1556 © The Animal Consortium 2015
doi:10.1017/S1751731115002438



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doi:10.1017/S1751731118000514

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Reproduction, Fertility and Development, 2018, 30, 101–117
<https://doi.org/10.1071/RD17376>

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RESEARCH ARTICLE

Prepubertal nutrition alters Leydig cell functional capacity and timing of puberty

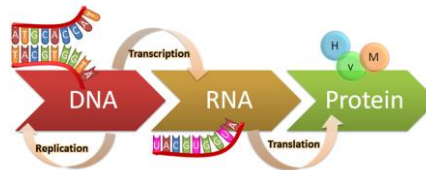
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Summary

- Enhancing early calfhood nutrition leads to:
 - ✓ earlier onset of puberty and availability of saleable semen
 - ✓ advanced steroidogenesis and testicular development
- No effect on fertility (IVF based)
- Identified key genes and molecular pathways in the brain and testes
- Validate these as part on a large on-farm bull fertility study
- Improved knowledge of complex biochemical regulation of sexual development
 - ✓ effective design of nutritional rearing regimens
 - ✓ identification of biomarkers for earlier sexual maturation and potentially improved fertility in the bull



Thank You!

