New opportunities for genomic selection in sheep and goats

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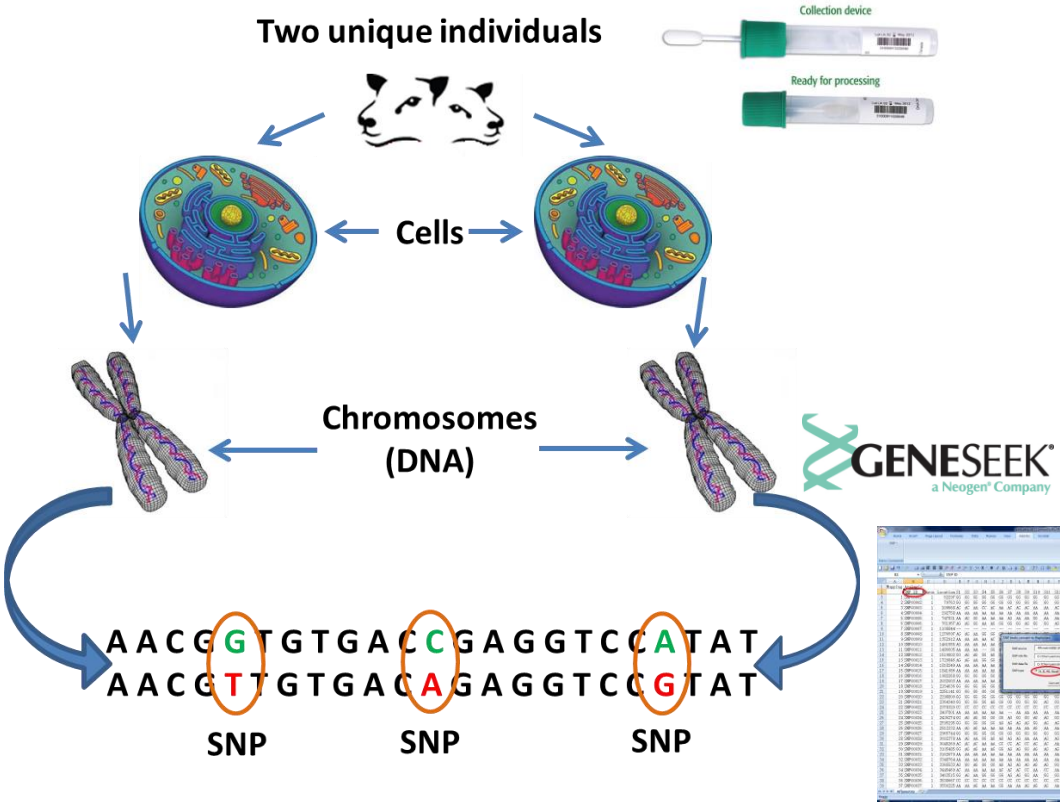
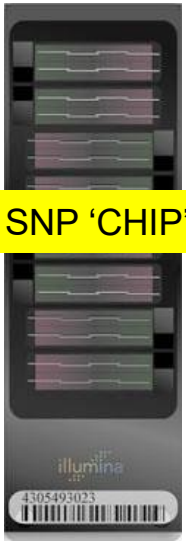
International Congress on the Breeding of Sheep and Goats, WCCB, Bonn, Germany 15 October 2020

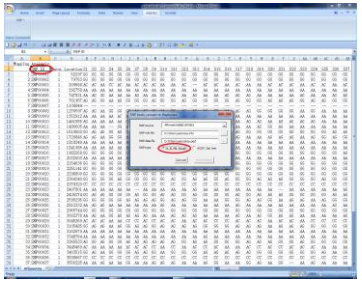
Leading the way in Agriculture and Rural Research, Education and Consulting

Using genomic data in breeding programmes





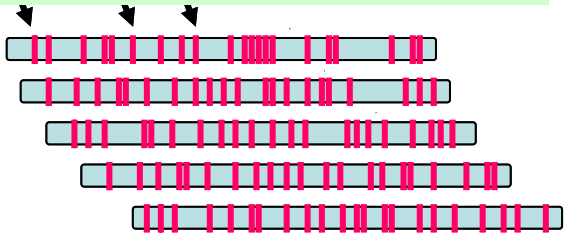
SNP 'CHIP'



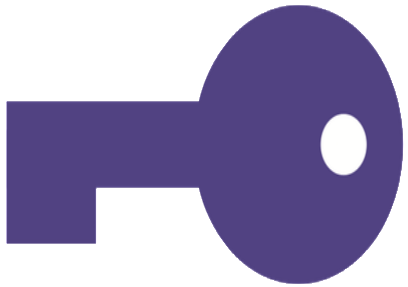
Genomic selection

- Dense map of markers (SNPs) across the genome (50K)

Markers (SNPs) spaced across all chromosomes



	SNP 1	SNP 2	SNP 3	SNP 4	SNP ……
Trait1	●	●	●	●	
Trait2	●	●	●	●	
Trait3	●	●	●	●	
Trait4	●	●	●	●	
Trait…	●	●	●	●	

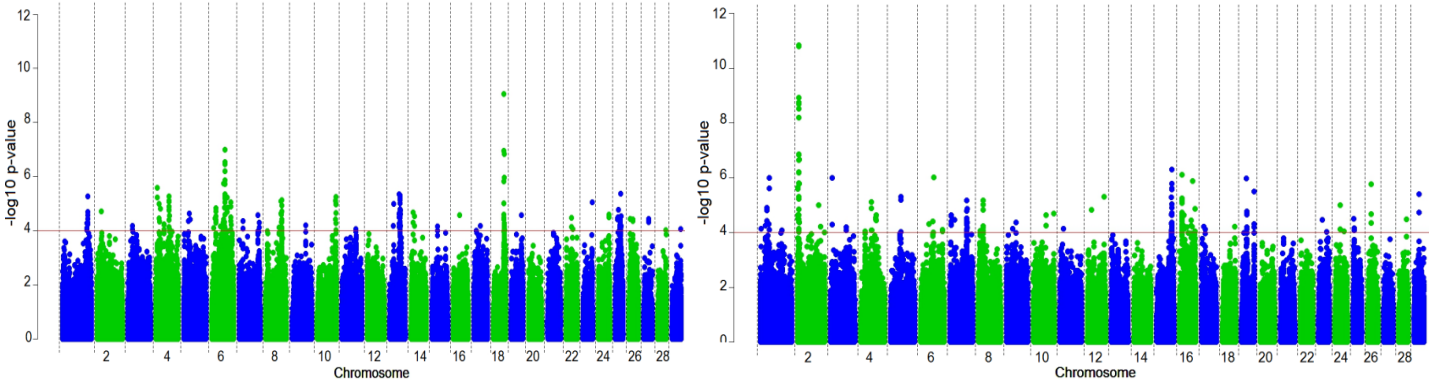


Genomic
Estimated
Breeding
Values

SNP ‘patterns’

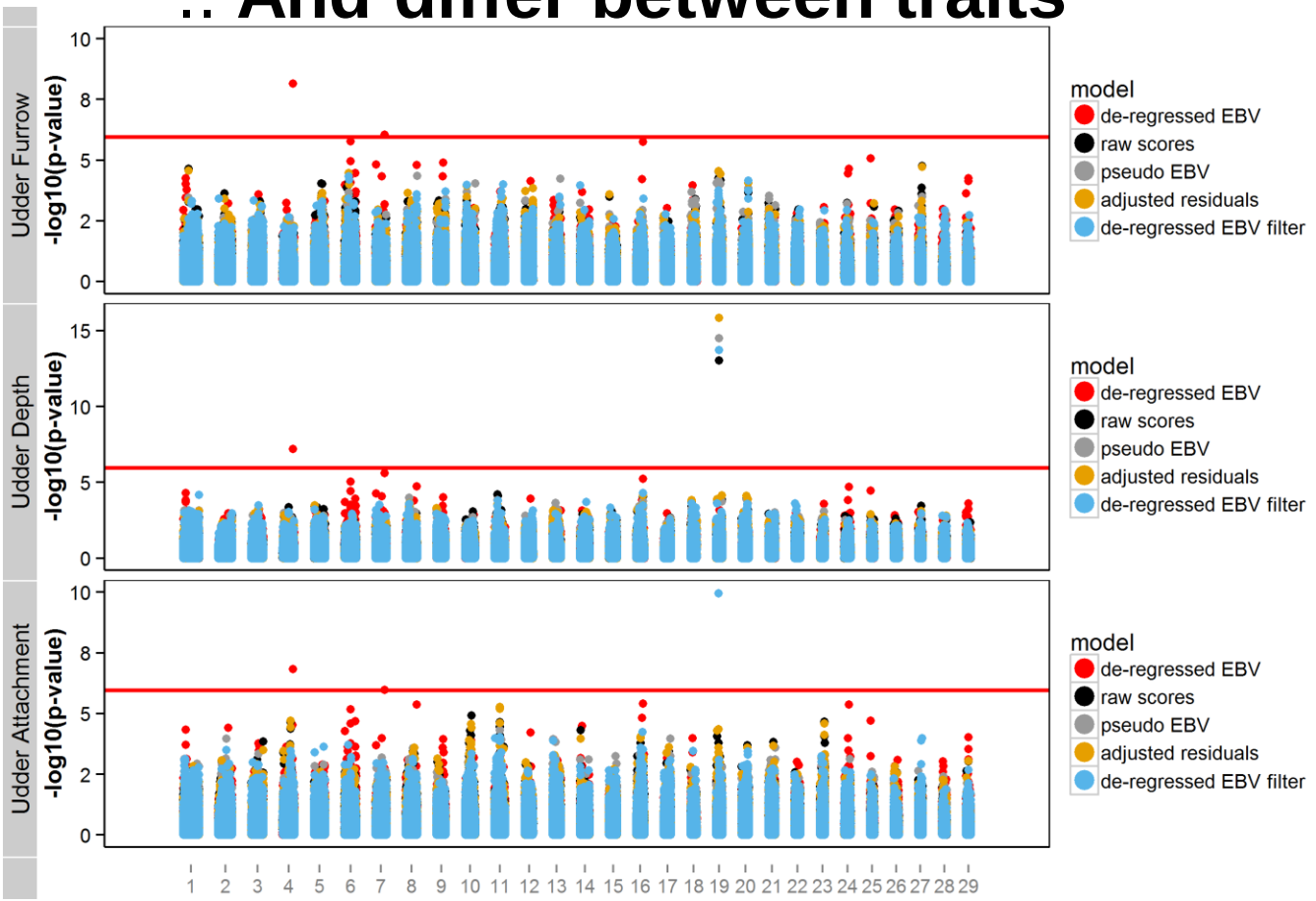
DNA effects can differ between breeds

Holstein **Dystocia** **Charolais**



Purfield et al., (2014)

.. And differ between traits

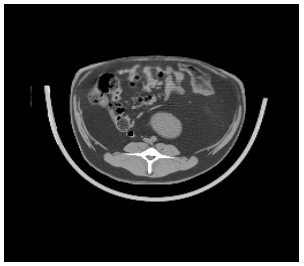


Mucha, Mrode, Coffey, Kizilaslan, Desire, Conington J. 2018 J. Dairy Sci.101(3):2213-2225

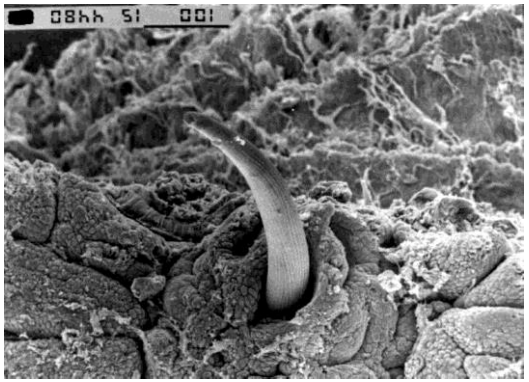
Hard to measure / expensive / measured later in life traits

Maternal traits
Longevity

Carcass &
Meat quality



Hard to measure / expensive / measured later in life traits



Disease

Smarter
SMAll RuminanTs breeding for Efficiency and Resilience

GrassToGas

Feed intake

(photo courtesy of H.Wishart)

Number of Texels with new disease phenotypes

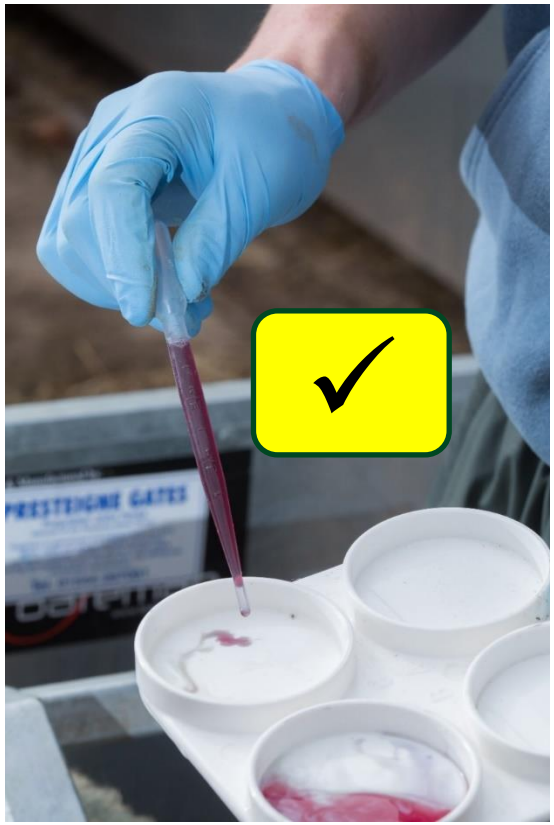
Year	No. ewes
2015*	3,339
2016*	3,482
2017	1,712
2018	1,652

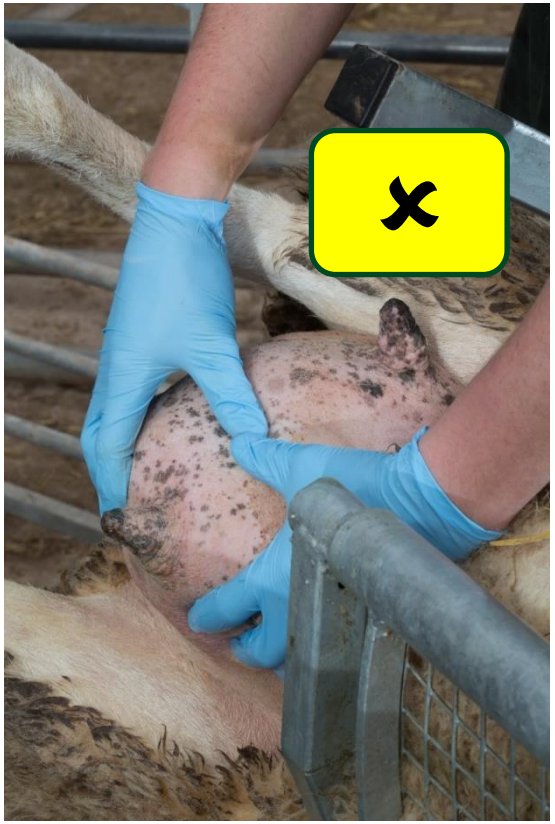
> 10,000 records

8,764 genotypes

*ewes scored twice @ 38 & 11

Mastitis ‘phenotyping’

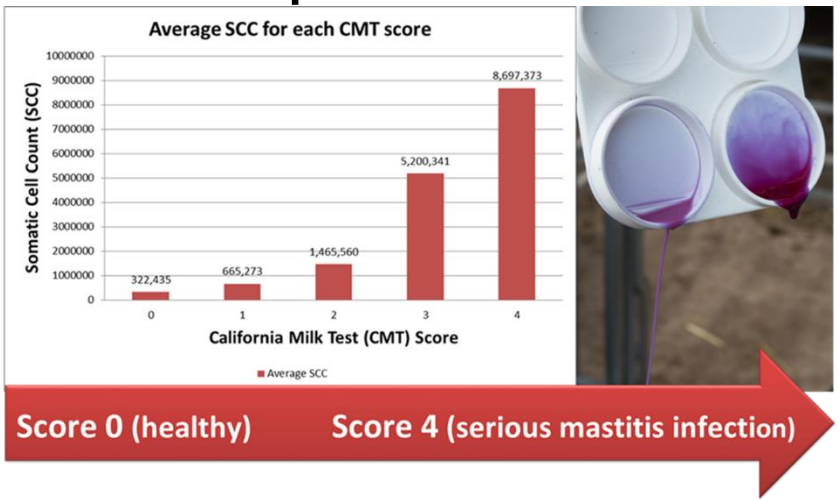


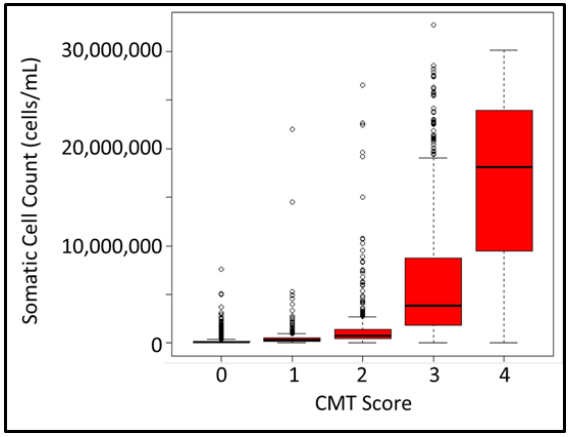


McLaren, A., Kaseja, K., Yates, J., Mucha, S., Lambe, N and Conington J. 2018 Animal 12:1-10

Somatic Cell Count vs CMT?

- Good predictor ✓



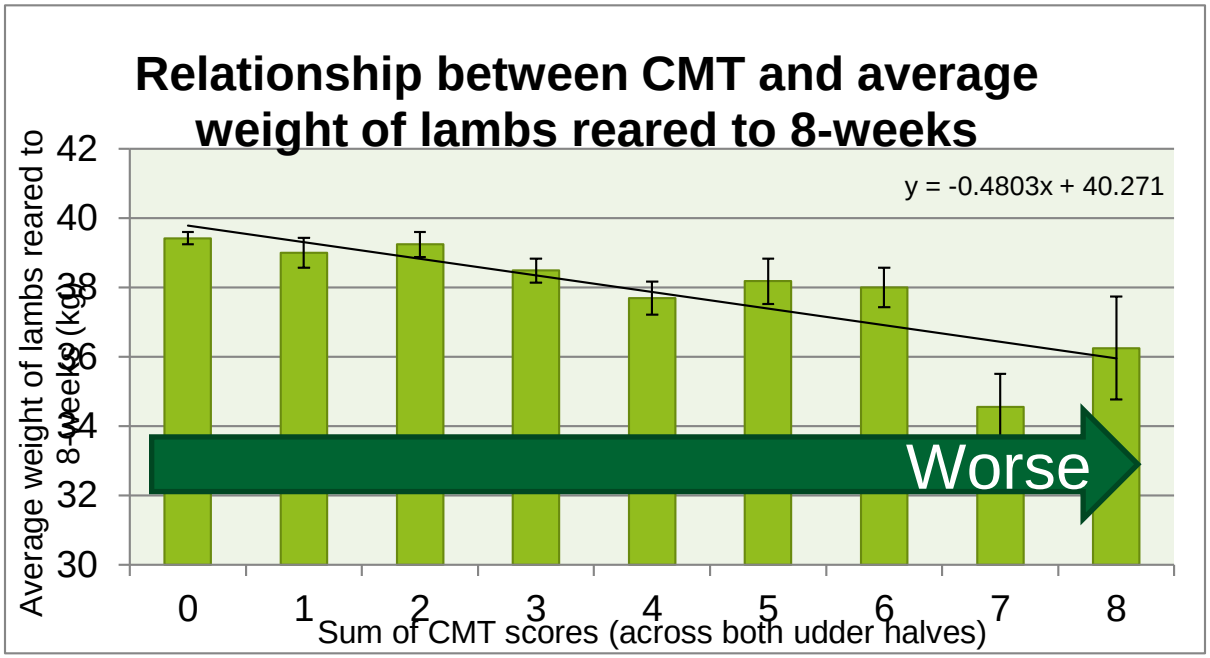


Trait	Heritability
CMT	0.14 (0.08)
SCC	0.23 (0.08)

Same (ish) genes

McLaren et al Animal 2018

CMT and lamb live weights



Difference between a ewe scored 0 and scored 8:

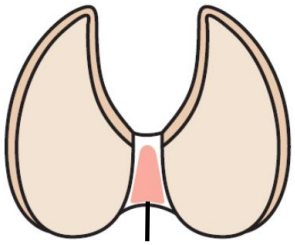
- 3.84 kg average lamb live weight reared
- £6.30 a lamb (live weight price of £1.64 per kilo)

Foot rot

Mucha et al Genet.Sel'n.Evol'n 2015

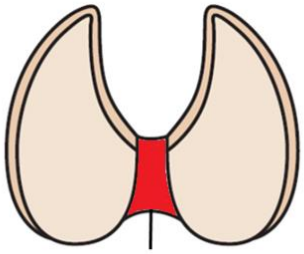
Foot scoring method

- 1: Non-specific inflammation of the interdigital skin



Interdigital dermatitis

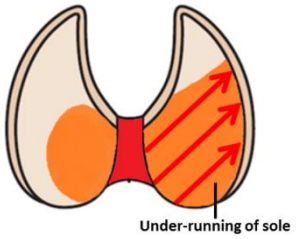
- 2: Necrotic, severe in



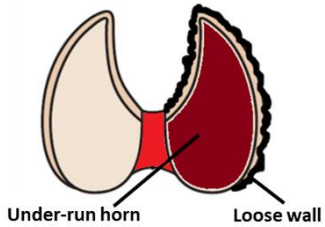
Severe inflammation

Foot scoring method

- 3: Under-run of the sole, restricted to soft horn of the heel



- 4: Under-run of the sole of the foot including the hard horn of the toe and wall



Conington et al., Vet Res Comm 2008

Resistance to Footrot is under low to moderate genetic control

Heritability 0.18

Breeding resistance to footrot

65

- Foot scoring useful tool to differentiate footrot & other hoof lesions
- 5-point scale, h^2 ~0.2

Conington et al., 2008 *Vet Res Comm.*
Nieuwhof et al., 2008 *Animal*

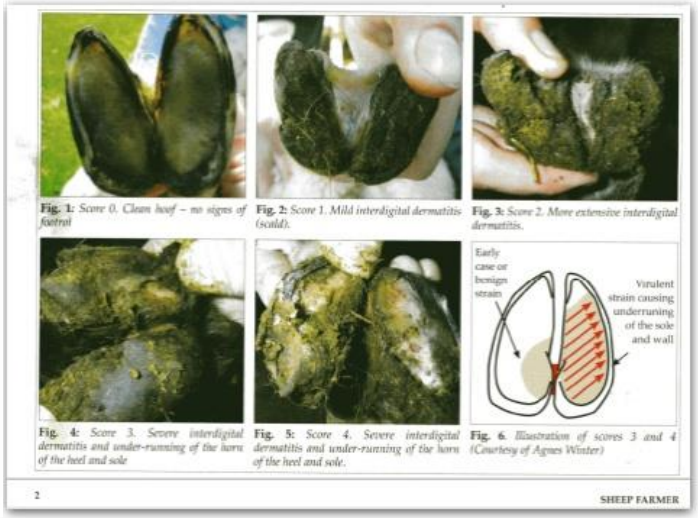


Fig. 1: *Score 0. Clean hoof – no signs of footrot*

Fig. 2: *Score 1. Mild interdigital dermatitis (scald).*

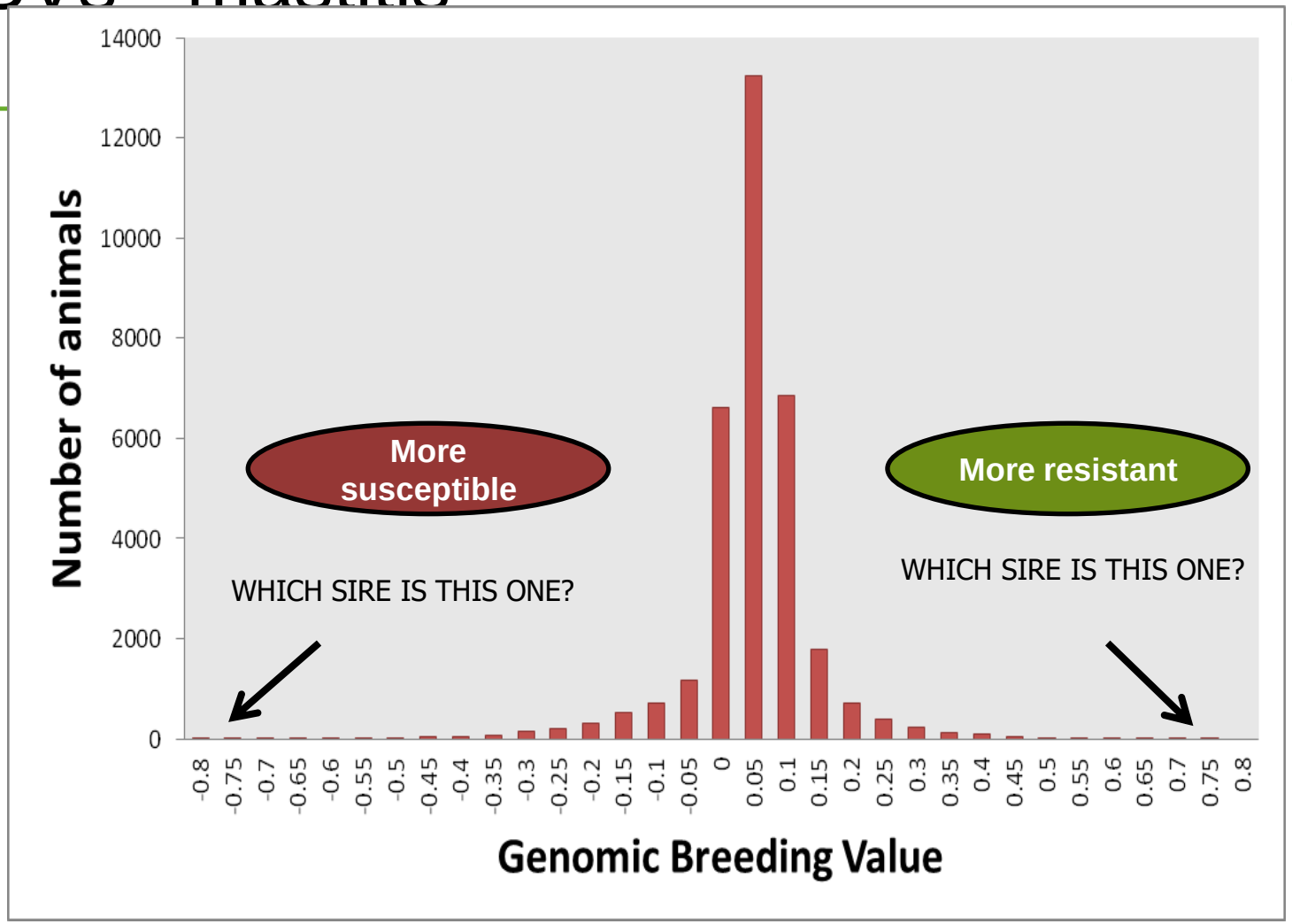
Fig. 3: *Score 2. More extensive interdigital dermatitis.*

Fig. 4: *Score 3. Severe interdigital dermatitis and under-running of the horn of the heel and sole*

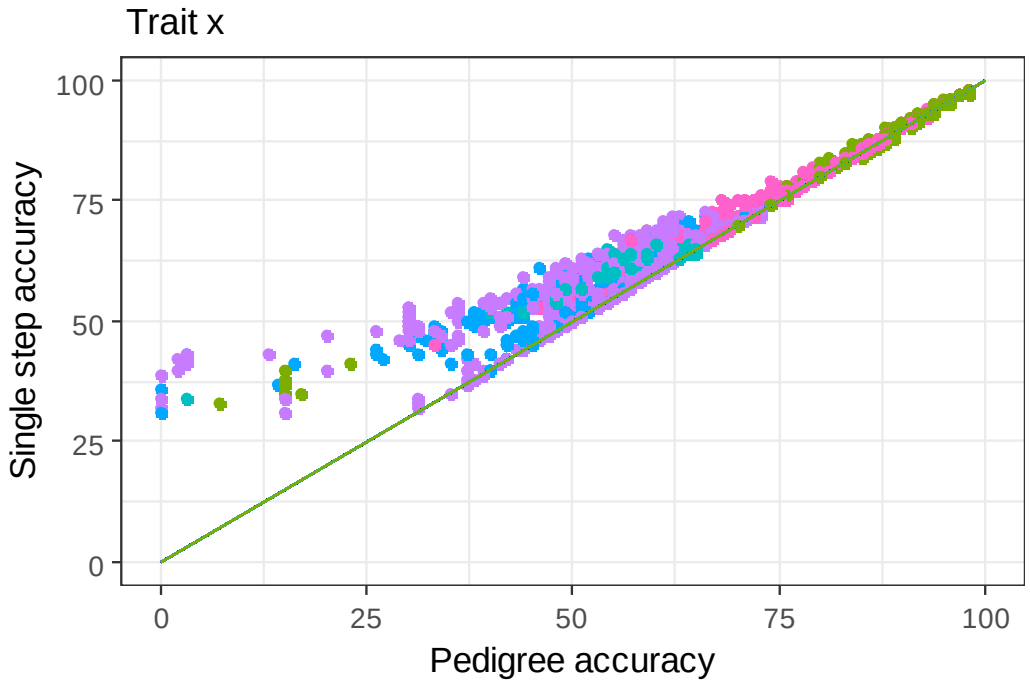
Fig. 5: *Score 4. Severe interdigital dermatitis and under-running of the horn of the heel and sole.*

Fig. 6. *Illustration of scores 3 and 4 (Courtesy of Agnes Winter)*

GEBVs - mastitis

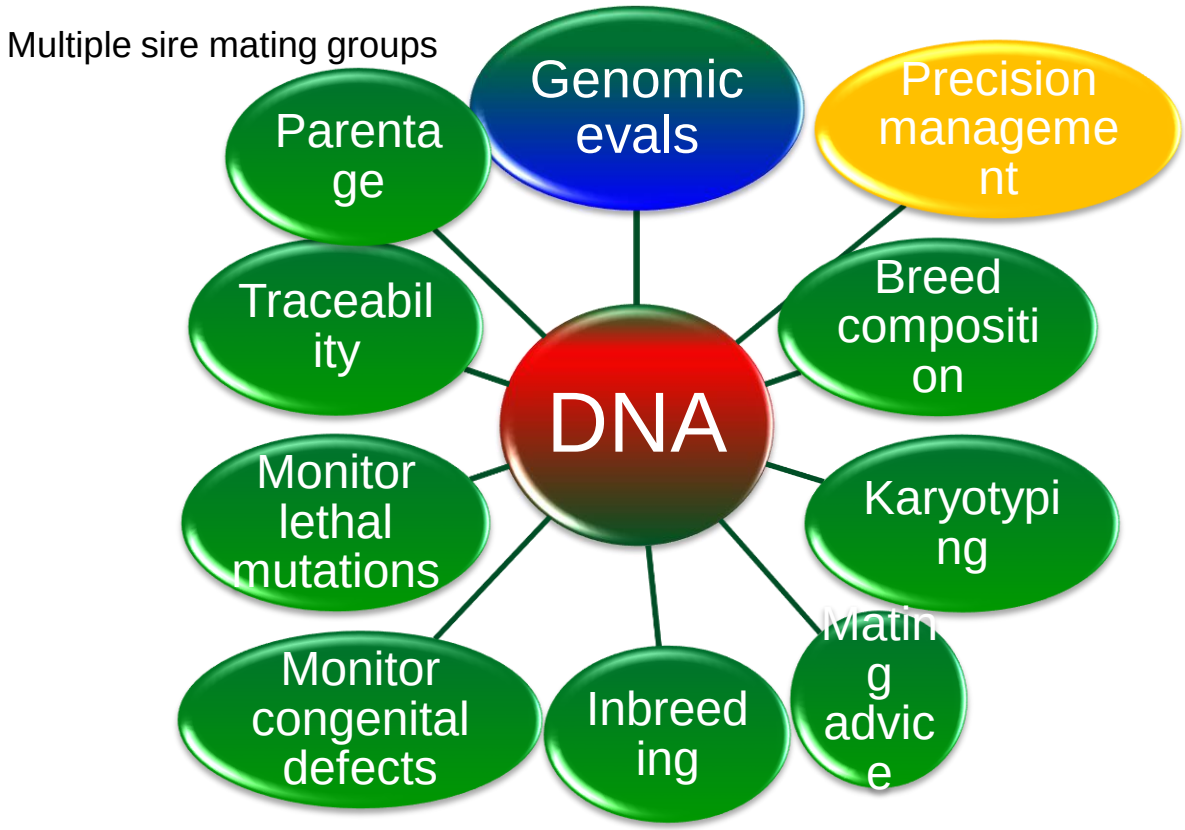


Genomic selection most beneficial when EBV accuracy is low



D. Brown, pers. comm 2018

What benefits ?



BEST OF BRITISH GOATS MILK
FRESH FROM THE FARM
St HELEN'S FARM
Cholesterol Free
Easy to Digest
Skimmed
Goats Milk
Deliciously Mild
Easy to Digest
Whole
Goats Milk
Deliciously Mild
Easy to Digest
Semi-Skimmed
Goats Milk
Goats Milk!
MATURE GOATS CHEESE
Blossom Honey
Blueberry & Rosehip
GOATS BUTTER
GOATS CHEESE

Example

- Dairy goat farm in UK
  - 2014 genomic selection
  - 14K genotyped goats (male & female*)
  - Earlier & more accurate identification of elite animals
  - Shorter generation interval
    - Pick replacements younger
  - Higher rate of genetic gain
    - 10- ~30%

YORKSHIRE DAIRY GOATS

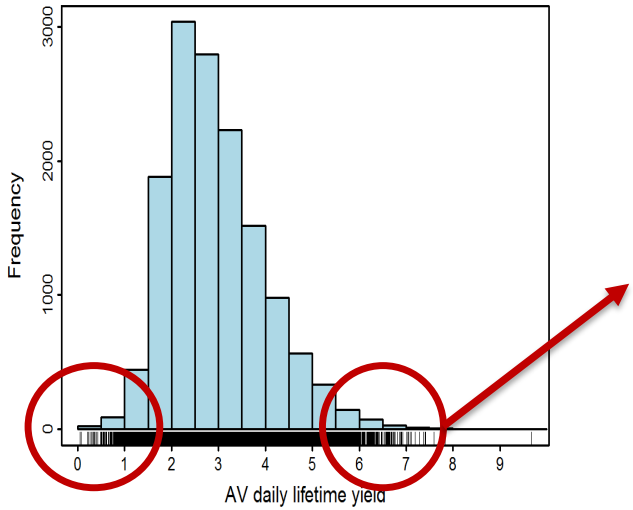
UK's largest Goat Milk producer
High-health Goats on 2 sites in East Yorkshire.

+SRUC (2011+)
+ ££

Unique genomic capability
Export & semen collection facility

YORKSHIRE DAIRY GOATS

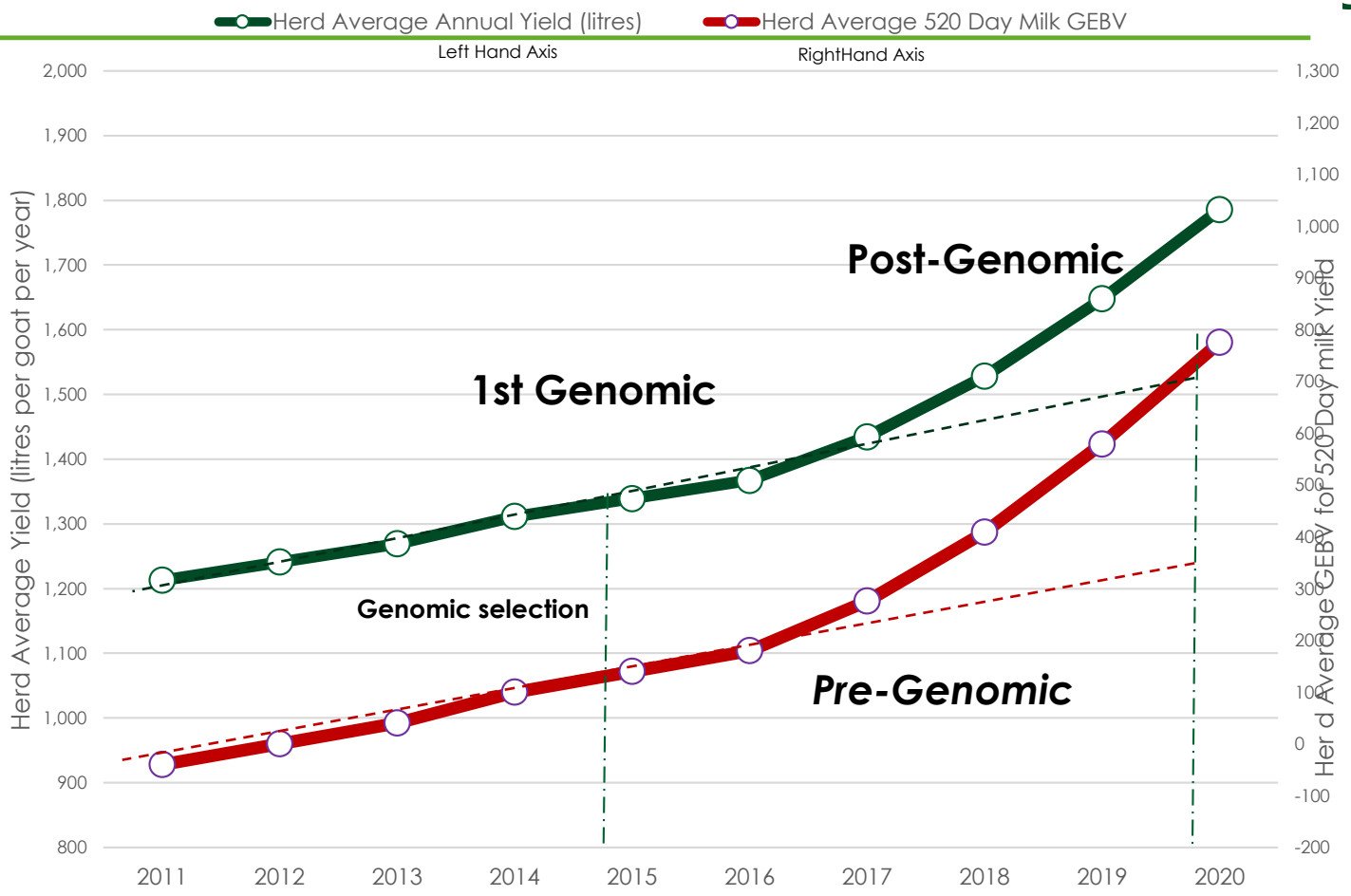
How did we start?



YORKSHIRE DAIRY GOATS

illumina®

Innovate UK
Technology Strategy Board


Herd Average Annual Yield (litres)
Herd Average 520 Day Milk GEBV
Left Hand Axis
RightHand Axis
Herd Average Yield (litres per goat per year)
Herd Average GEBV for 520 Day milk Yield
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
-100
-200
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Post-Genomic
1st Genomic
Genomic selection
Pre-Genomic

Sheep?

- Australia ✓
- NZ ✓
- France (dairy sheep, within-breed) ✓
- Ireland ✓
- UK (Texel) routine planned for 2020 ~✓
  - COVID delay

France – sorting out the reference population

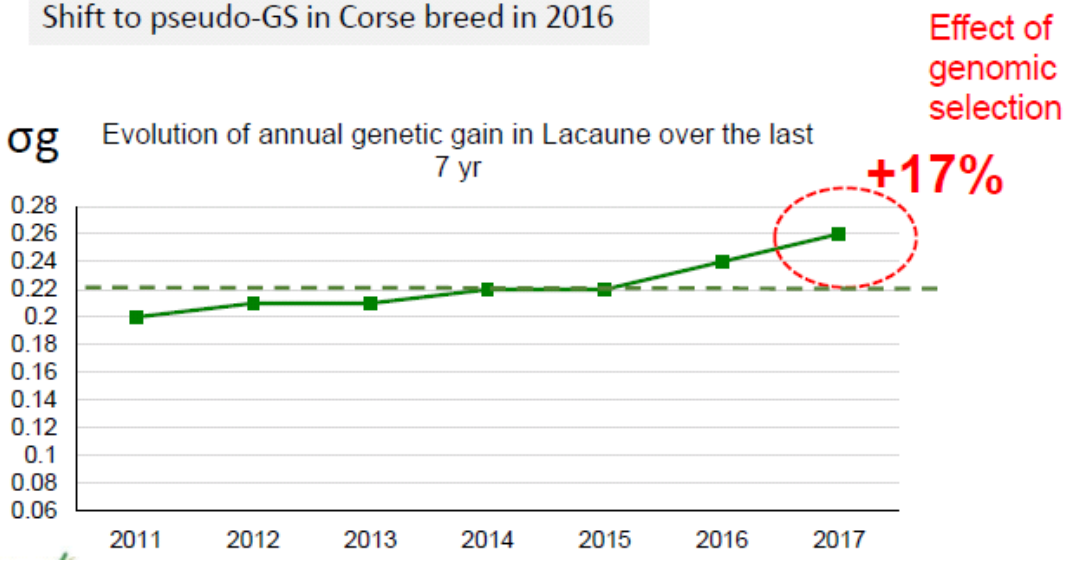
Situation in 2018	Genotyped rams	With daughters	Reference population depth	1er complete year of birth
Lacaune	13212	**5368**	1996-2017	2003
RF Manech	3007	**2238**	1998-2017	2000
Basco-Béarnaise	945	**667**	1999-2017	1999
BF Manech	643	**510**	1996-2017	1996
Corse	746	**243**	2001-2017	2005

Courtesy of J.M. Astruc, 2018

Proof it works - France

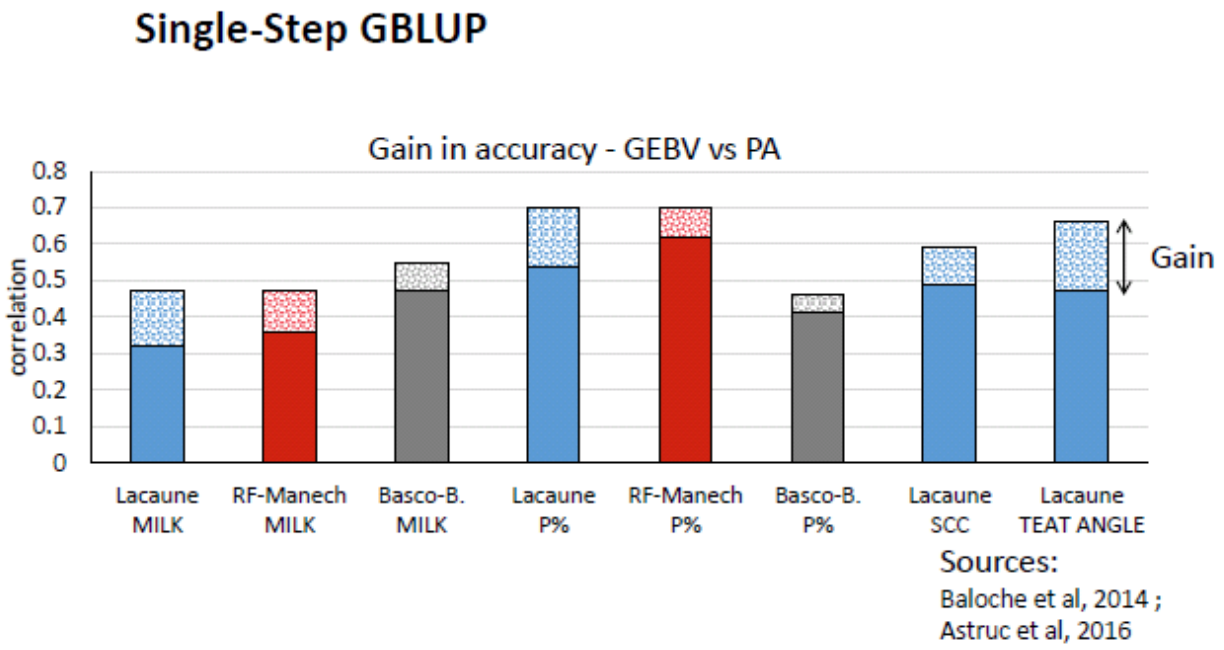
Genomic selection: first results observed in Lacaune breed

Shift to GS in Lacaune breed in 2015
Shift to GS in Pyrenean breeds in 2017
Shift to pseudo-GS in Corse breed in 2016



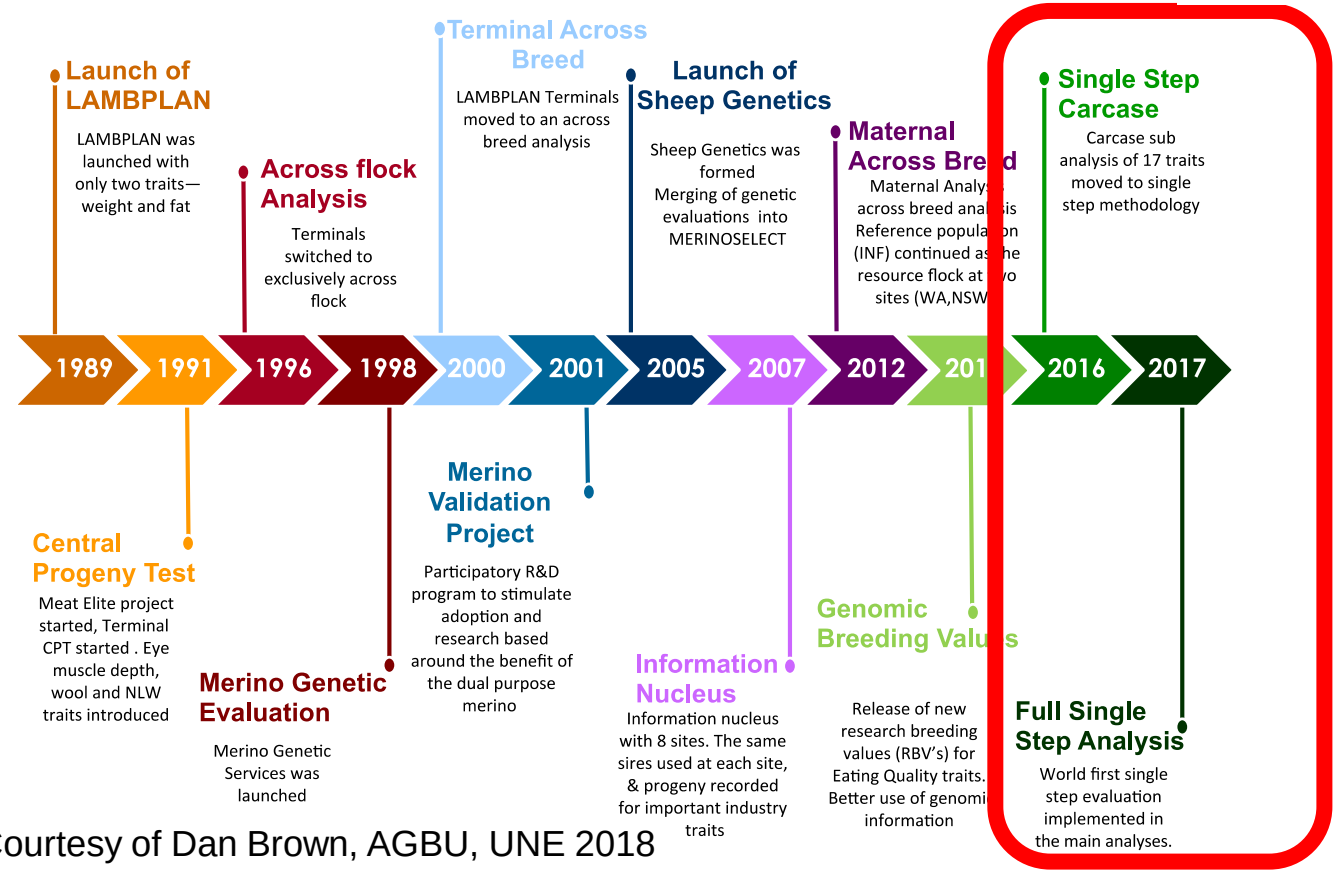
Courtesy of J.M. Astruc, 2018

More proof it works - France



Courtesy of J.M. Astruc, 2018

Australia GS timeline

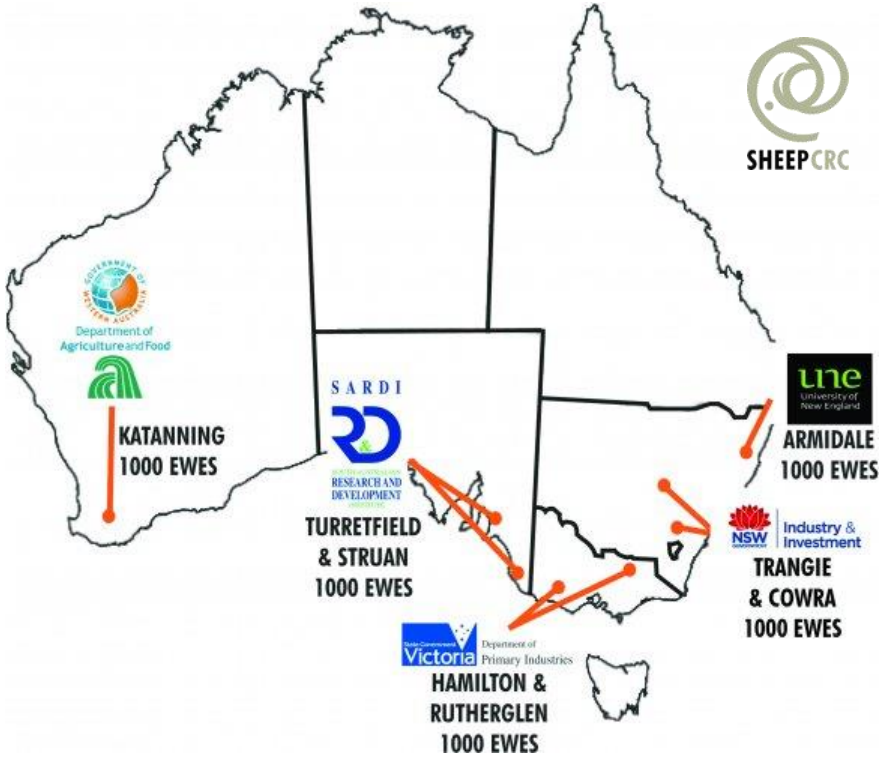


Courtesy of Dan Brown, AGBU, UNE 2018

Reference population design

- Eight sites across Australia
- Mostly Merino ewe base
- 100 sires mated annually
- Comprehensive phenotyping of progeny
- 50K SNP genotypes

  + (15K, HD, Seq)

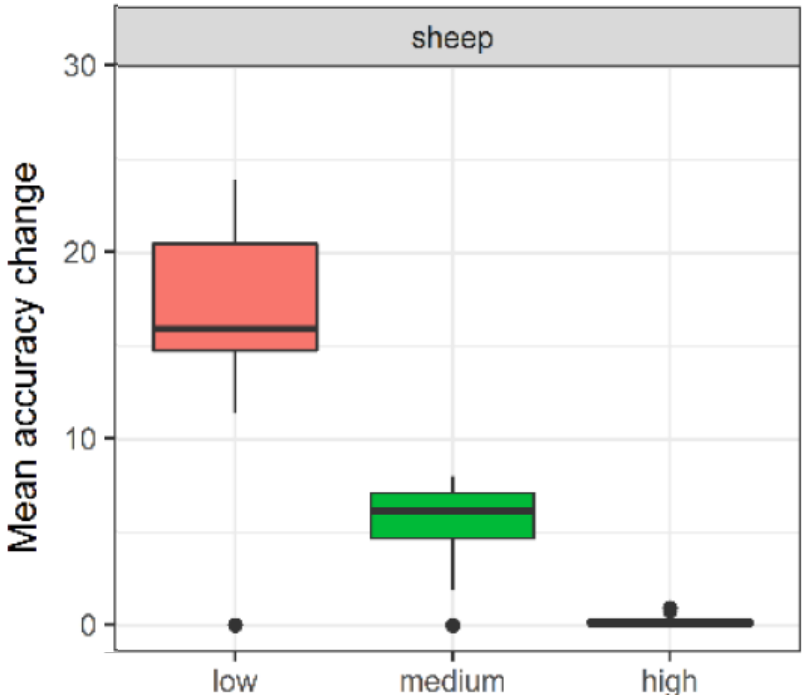


Courtesy of D. Brown, AGBU, UNE 2018

The Genomic Reference Population

Courtesy of Dan Brown, AGBU, UNE 2018

Improvement in accuracy of using genomic selection vs ABLUP accuracies within bands of ABLUP accuracy from low (<30), medium (30 – 50) and high (>50)



Australian EBV accuracies

Li et al 2018 AAABG

Conclusions

- Genomic selection is now operating in sheep and goat populations around the world
- Hard to measure / expensive traits ideal targets
  - Cheap & cheerful phenotypes – lots needed
- Key benefit is increase in accuracy
  - Reduces risk of selection
- Associated benefits of using genomic info
  - Healthier, higher welfare

Acknowledgements

Ann McLaren
Nicola Lambe
Sebastian Mucha
Karolina Kaseja
Antonio Pacheco
John Yates (TSS)

SRUC

REF2014 Research Excellence Framework — Ranked #1 in the UK for Agriculture, Veterinary and Food Science

BBSRC bioscience for the future

FACCE ERA-GAS

ERA-NETSUSAN

ICT AGRI era-net

TEXEL SHEEP SOCIETY

The Scottish Government

Innovate UK Technology Strategy Board

Smarter
SMAll RuminanTs breeding for Efficiency and Resilience

SRUC

Leading the way in Agriculture and Rural Research, Education and Consulting