Instituto Nacional de Investigación Agropecuaria
URUGUAY

Experiences in the use of genomics in ruminants in Uruguay

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Uruguay

ICAR 2016, Puerto Varas, Chile

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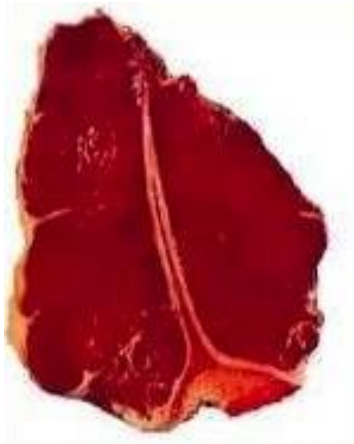
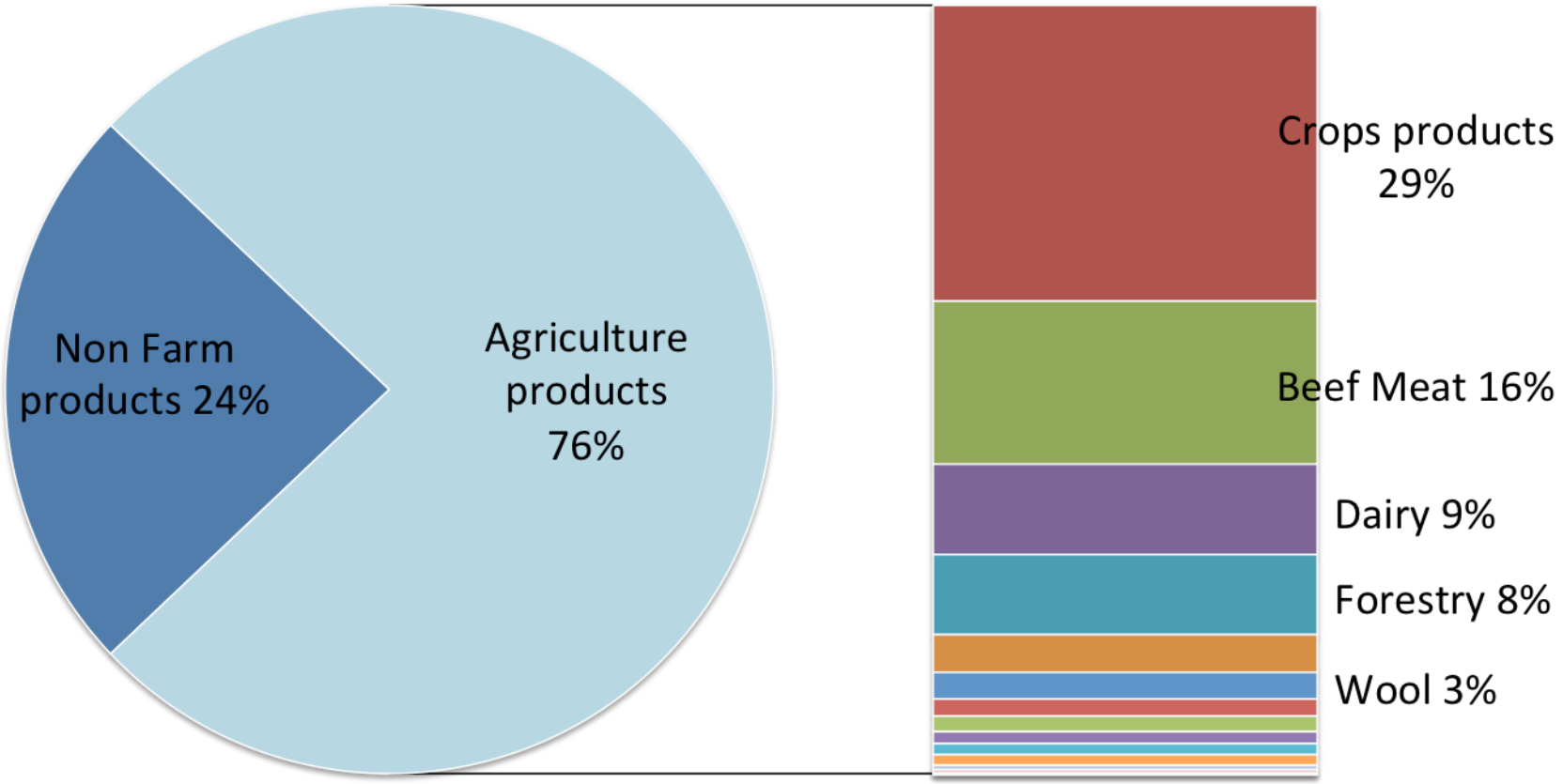
Uruguay



Agro-exporting country



DIEA – MGAP 2015

Livestock production

Beef cattle

- 11.8 m
- 1070 k ton meat

Dairy cattle

- 770 k animals
- 440 k cows
- 2200 mil lt

Sheep

- 7.4 m
- 60 k ton meat
- 30 k ton whool

Livestock genetic improvement

National genetic evaluations

- Beef Cattle
  - Hereford
  - Angus
  - Braford
  - Limousine
- Dairy Cattle
  - Holstein
  - Jersey
- Sheep
  - Corriedale
  - Merino
  - Polwarth
  - Merlin
  - Romney Marsh
  - Texel
  - Hampshire Down
  - Ile de France
  - Poll Dorset
  - Highlander

Animal Genomic DNA Bank
INIA Las Brujas

Animal Genomic DNA Bank

- Integrated technology platform to implement genomic and other “omics” research projects
- Base for the generation of training populations for genomic selection in sheep, beef and dairy cattle

Animal Genomic DNA Bank

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Breed	Number of samples	Population type
Merino	~ 4700	Stud/Research
Corriedale	~ 3800	Stud/Research
Texel	~ 800	Stud
Angus	~ 2000	Stud
Hereford	~ 4900	Stud
Holando	~ 2000	Stud/Commercial
Creole	~ 400	Research
Other Breeds	~ 2000	Research

“SNP Assisted Breeding” for Sheep extensive systems

Very Low Density SNP panel: Development

VLD SNP panel: development

SNPs	Purpose	reference
250	INIA Parentage preselected (50k)	INIA Project (+ ANII)
69	ISGC Parentage	Kijas et al., 2012
2	Horn/Poll	Dominik et al. 2011; Johnston et al. 2011
174	FEC associated (16 from 50k)	INIA Project
7	Merino Breed specific	INIA Project (QC, population genetics, crossbreeding, prolific, etc.)
5	Corriedale Breed specific	

Agreement between

EUREKAGENOMICS

INIA

Parentage SNPs: Uruguayan panel

Panel	n	Criteria
1	83	Min Nº PE of 0.9999 for Corriedale, Merino and Texel
2	96	P1+7 rare SNP (>0-0.1) and 10 SNP MAF 0.1-0.4
3	141	P2+ Kijas et al., 2012 (pass QC citeria)
4	154	P3+ FEC (pass QC criteria)
0 Total	**258**	P4 + others parentage SNP

Panel	Corriedale	Merino	Texel
1	0.9999033	0.9999099	0.9999045
2	0.9999871	0.9999961	0.9999497
3	0.9999999...	0.9999999...	0.9999992
4	0.9999999...	0.9999999...	0.9999997
0 – Total	**0.9999999...**	**0.9999999...**	**0.9999999...**

$$P = 1 - 4\sum_{i=1}^{n} p_i^2 + 2\left(\sum_{i=1}^{n} p_i^2\right)^2 + 4\sum_{i=1}^{n} p_i^3 - 3\sum_{i=1}^{n} p_i^4$$

PE: combined exclusion probability according to Jamieson & Taylor, 1997

FMV_2_2011_1_6356

Merino Breeding Nucleus

Results Merino Breeding Nucleus (2015)

2 Dic 15: 200 samples sent to USA. (100 lambs, 9 sires, 91 dams)

7 Dic: samples arrived to USA

14 Dic: Affymetrix send genotype data.

16 Dic: Parentage verification and horn/poll

17 Dic: first distribution of ram with DNA parentage verification.

Call rate= 0.9937

13 samples fail (9 in the same plate)

affymetrix

EUREKAGENOMICS.

Parentage SNP: Errors of assignments

Parentage assignments (Sire-lamb): % error (Nº of pairs) by breed and stud

Breed		A	B	C	D	E	F	G	NUG
Corriedale	% error	15.7	0.0	0.0	16.7	16.6	14.0	3.2	
	n	51	7	28	6	139	43	63	
Merino	% error	5.0	4.9	4.8	6.3	11.0	0.0	66.7	6.3
	n	40	41	21	112	73	22	6	223

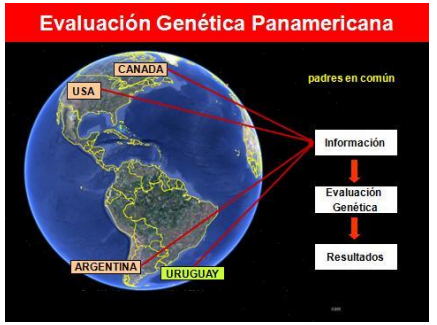
Opportunities for the VLD SNP panel

cheap sheep chip

1. Improve genetic gain: parentage verification
2. Increase Ram price by "parentage certified stamp"
3. Official use for pedigree animals (ARU)
4. Increase Ram price by "Poll allele stamp"
5. Reduce cost of labor (parentage assignment in field)

Hereford Breeding Programme

- **Genetic evaluation system in place**
  - 280 thousands animals in the current database, 350 studs
  - Per year: 10000 new animals of 160 studs



- **Member of the Pan-American genetic evaluation**

- **Twice a year Expected Progeny Differences of breeding animals are published and available for several relevant traits**
  - Birth, weaning, 15-month and 18-month weights
  - Cow adult weight and milk
  - Eye muscle area and fat depth by ultrasound
  - Scrotal circumference
  - Selection index cow-calf operation

HEREFORD URUGUAY

INIA

International Hereford Project

- Sociedad Criadores de Hereford del Uruguay
- National Beef Cattle Evaluation Consortium (USA)
- Asociación Rural del Uruguay
- Instituto Nacional de Investigación Agropecuaria

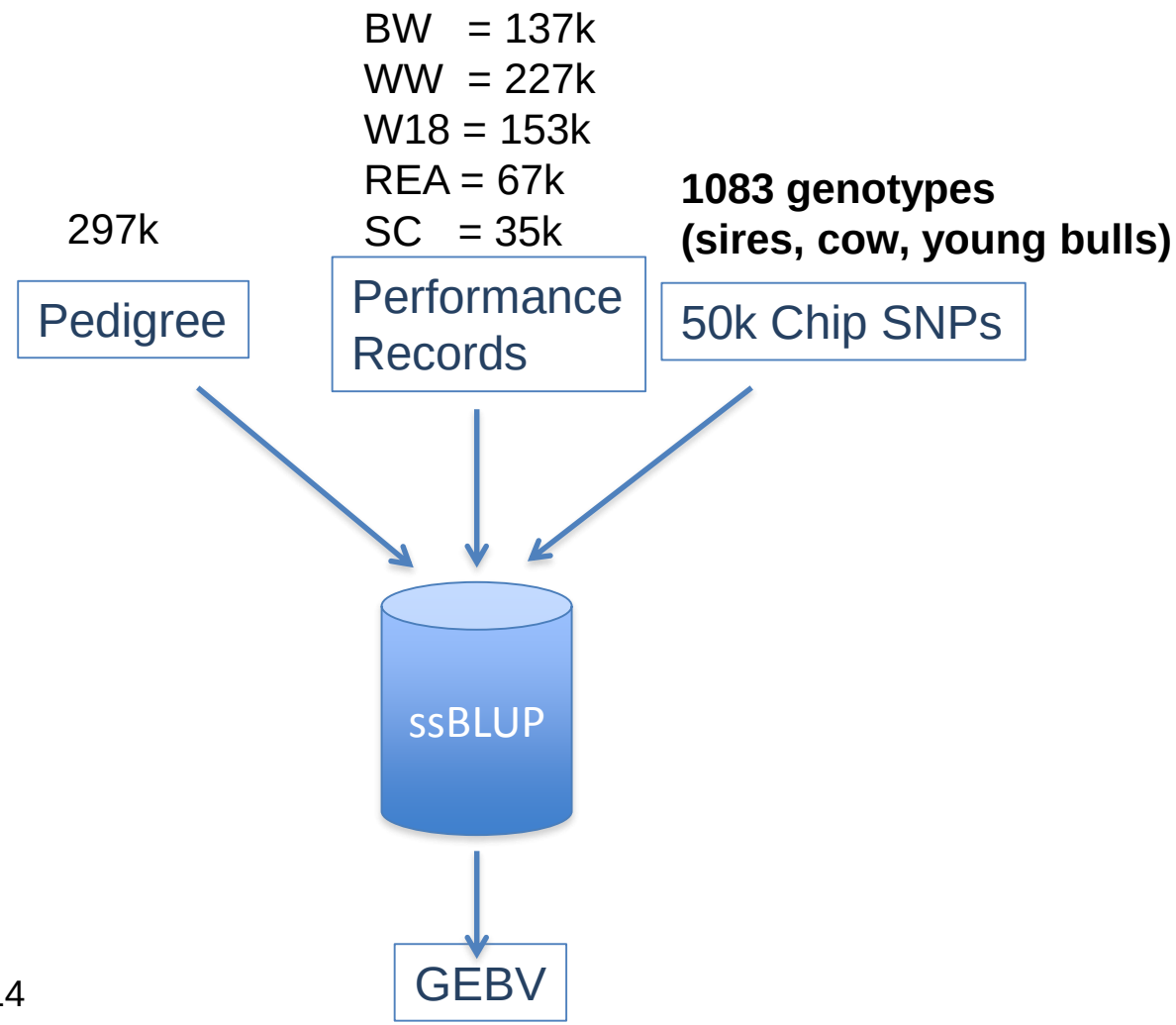
Build a training population for genomic selection in Uruguayan Hereford

Validation of prediction equations from PanAmerican training population

Uruguayan Hereford Genomic Population

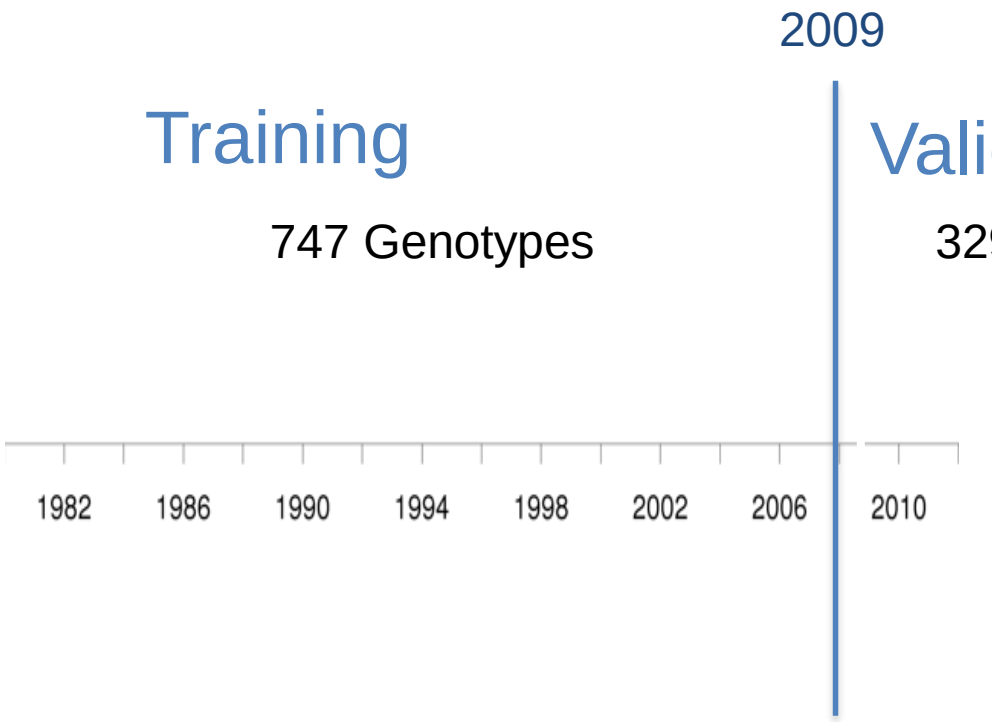
- ~ 1100 Hereford animals (males & females)
- Colaboration:
  - **Hereford breeders**
    - Hair, blood and semen samples from high accuracy sires
  - **16 Hereford Studs**
    - Young bulls from generation 2010 + sires
  - **AI companies**
  - **National Herd-Book (ARU)**
    - Hair samples. Agreement ARU – INIA

Genomic predictions - Hereford Uruguay
Single Step GBLUP



Aguilar y Ravagnolo 2014

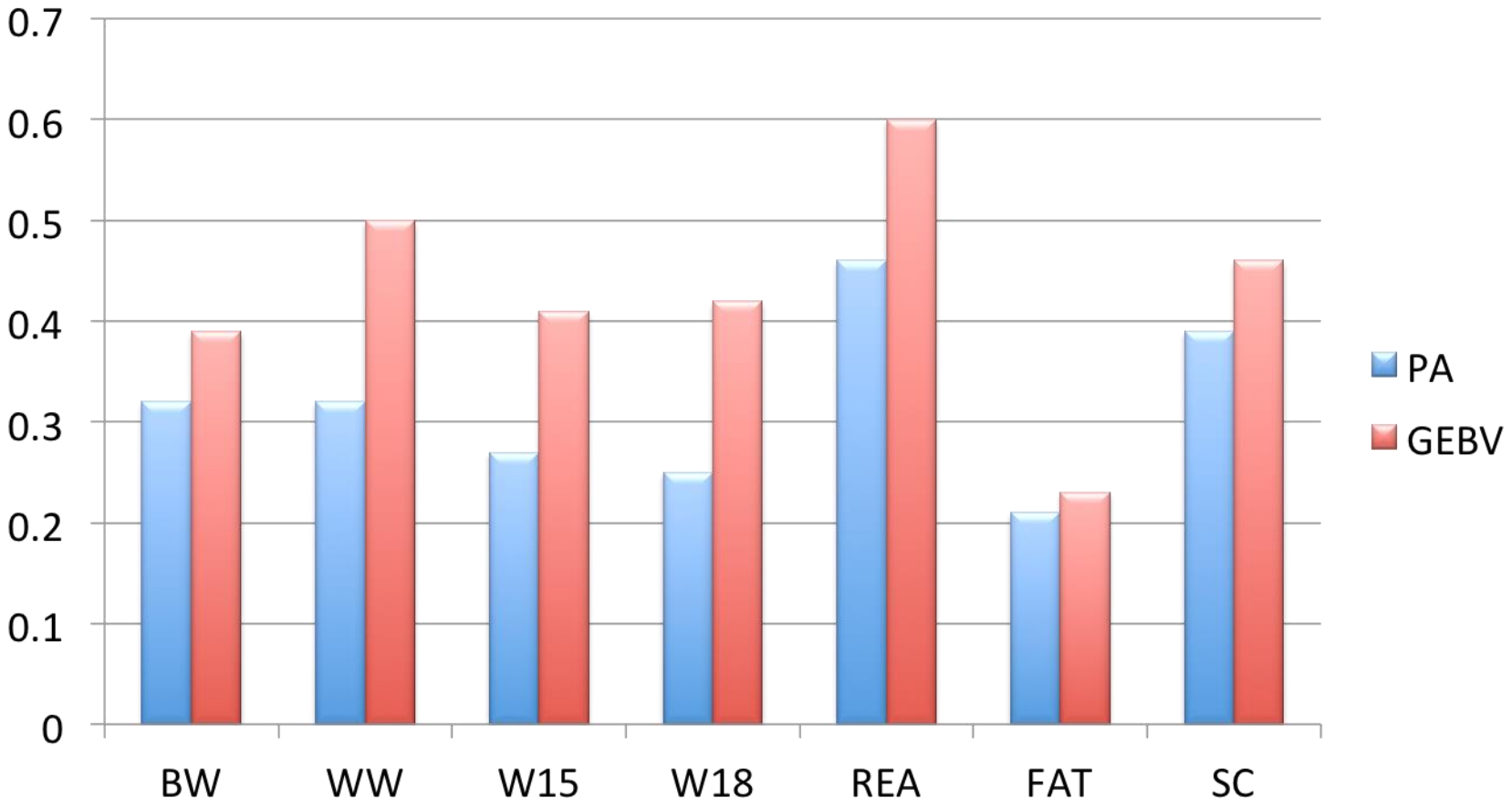
ssGBLUP Hereford Uruguay Cross Validation



1) Remove Phenotypes
2) Genetic Evaluation
   - Traditional
   - Genomic
3) Correlation with Y
4) ACC = Cor (GEBV,Y) / h

Aguilar y Ravagnolo 2014

ssGBLUP Hereford Uruguay Cross Validation



Aguilar y Ravagnolo 2014

PanAmerican Genetic Evaluation

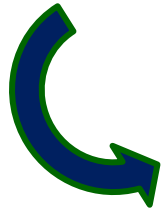
- **Official GE-EPDs for Uruguayan Hereford since August 2016**
- **Genomic predictions available for breeders for next evaluation December 2016**
- **Industry adopting the technology**

Genetic improvement: feed efficiency & carcass quality

- **Genetic improvement by "traditional" selection limited because of:**
  - Difficulties and high cost of data recording
  - Longer generation interval (i.e. progeny testing for carcass and meat quality)
  - Low selection intensity due to low number of animals with data for any of these traits

- **Genomics in animal selection**

- **Integration of genomic information into genetic evaluation :**
  - Increase genetic gain by higher accuracy at early ages
  - Animals with EPD estimated using genomic information



- **Building training (reference) populations**

Enhancing competitiveness of the Uruguayan beef industry by implementing genomic tools to genetically improve feed efficiency and carcass quality of Hereford breed

- Three years project:
  - Jan 2014 – Jan 2017
- Consortium of public and private organizations
- Funding: US$ 2 million
  - 25% Hereford Breeders
  - 35% Other institutions
  - 45% National funding

HEREFORD URUGUAY — Hereford Breeders Association

Rural Association — Asociación Rural del Uruguay

INIA URUGUAY — National Agriculture Research Institute

Ministry of Agriculture — Ministerio de Ganadería, Agricultura y Pesca, República Oriental del Uruguay

Uruguay inac — National Meat Institute

Biological Research Institute — IIBCE

ANII — Agencia Nacional de Investigación e Innovación

INIA

Feed efficiency

EFICIENCIA HEREFORD
Genómica para un Uruguay sostenible

TRAINING POPULATION FEED EFFICIENCY		YEARS		
ANIMALS	INTAKE TEST PHASES	2014	2015	2016
BULLS autumn calving	Adaptation Warm-up TEST	Test 1 50 animals 11 herds	Test 4 49 animals 11 h	Test 7 45 animals
BULLS spring calving	Adaptation Warm-up TEST	Test 2 120 animals 39 herds	Test 5	
STEERS	Adaptation Warm-up TEST	Test 3 113 animals 5 herds	T	

626 Hereford animals
Sired by 200 bulls
From 60 breeding herds

- Animal age
- By origin: from at least two sired
- Bulls:
  - ✓ in genetic evaluation
  - ✓ with birth and weaning weights
- Steers:
  - ✓ pedigree sires in genetic evaluation (confirmed by DNA)

Close to the target of 1000 animals

Good representation of herds in genetic evaluation

Linked to Hereford population

Canada – Uruguay
Collaborative Project on Feed Efficiency

March 2016

OBJECTIVES

International genetic evaluation

Integration training populations

Genomic associations studies

PRODUCTS

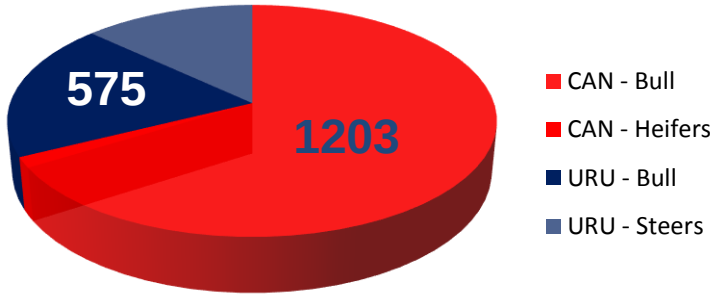
Estimated Progeny Differences

Genomic EPD

Significant genome regions

- **Joint databases**

Feed efficiency phenotypes



- Phenotypic records of purebred animals
  - Similar test trials protocols
- Pedigree data
  - Unification of databases using international animals ID
  - 4 generations of animal with feed efficiency records
  - ~ 7000 animals (CAN+UY)
  - Need to improve genetic connexion

Canada – Uruguay
Collaborative Project on Feed Efficiency

OBJECTIVES

International genetic evaluation

Integration training populations

Genomic associations studies

PRODUCTS

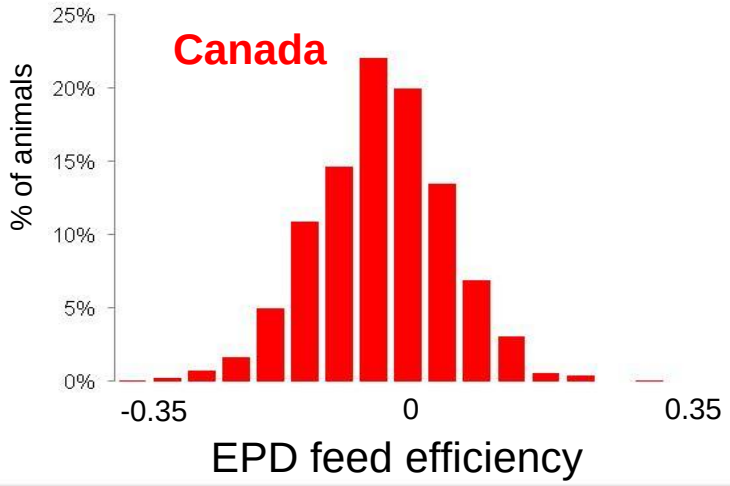
Estimated Progeny Differences

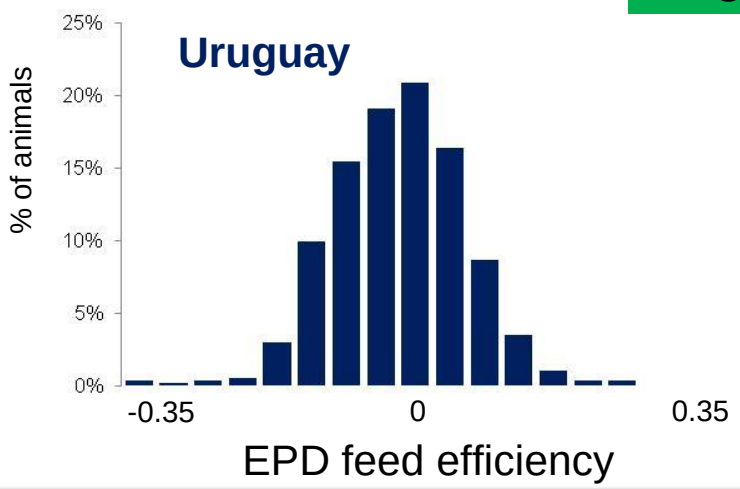
Genomic EPD

Significant genome regions

- **Data analysis**
  - Calculation of residual feed intake (RFI)
  - Estimation of Expected Progeny Differences (EPD)
    - First step: feed efficiency as RFI
    - Larger database: selection index

Published in August 2016





Canada – Uruguay
Collaborative Project on Feed Efficiency

OBJECTIVES

International genetic evaluation

Integration training populations

Genomic associations studies

PRODUCTS

Estimated Progeny Differences

Genomic EPD

Significant genome regions

- **Integration of training populations (genomic data)**
  - URUGUAY: 1000 bulls and steers with phenot
    + 1100 genotypes with genetic ev
  - CANADA: 400 bulls (700k SNPs) + 1900 bulls an

2017

Publishing genomic EPDs
4000 CAN & UY
genotyped animals

GENOMIC EPD

- Estimated with larger training populations
  - ✓ **Higher accuracies**
  - ✓ **Stronger connectivity** between populations
- Larger number of animals with EPDs and comparable
  - ✓ **High selection intensity**

Training population

carcass and meat quality

TRAINING POPULATION FEED EFFICIENCY	
ANIMALS	INTAKE TEST PHASES
BULLS autumn calving	Adaptation
	Warm-up
	TEST
BULLS spring calving	Adaptation
	Warm-up
	TEST
STEERS	Adaptation
	Warm-up
	TEST

- **Steers after feed efficiency evaluation are finished on grass (+concentrate).**

- **Carcass traits:**
  - hot and cold carcass weight,
  - conformation and fatness grades,
  - quarters, primal and cuts weights.
- **Meat quality:**
  - meat and fat colour,
  - intramuscular fat percentage,
  - pH, tenderness (Warner Braztler), and fatty acid profile

Training population

carcass and meat quality

TRAINING POPULATION FEED EFFICIENCY	
ANIMALS	INTAKE TEST PHASES
BULLS autumn calving	Adaptation
	Warm-up
	TEST
BULLS spring calving	Adaptation
	Warm-up
	TEST
STEERS	Adaptation
	Warm-up
	TEST

+

Research project

- **Steers with know paternity**
- **Progeny from Sires with EPD in National Genetic Evaluation**
- **Similar slaughter protocols and measures**

TRAINING POPULATION

so far:

- 755 steers
- Genotypes
- 80k / 700k SNP

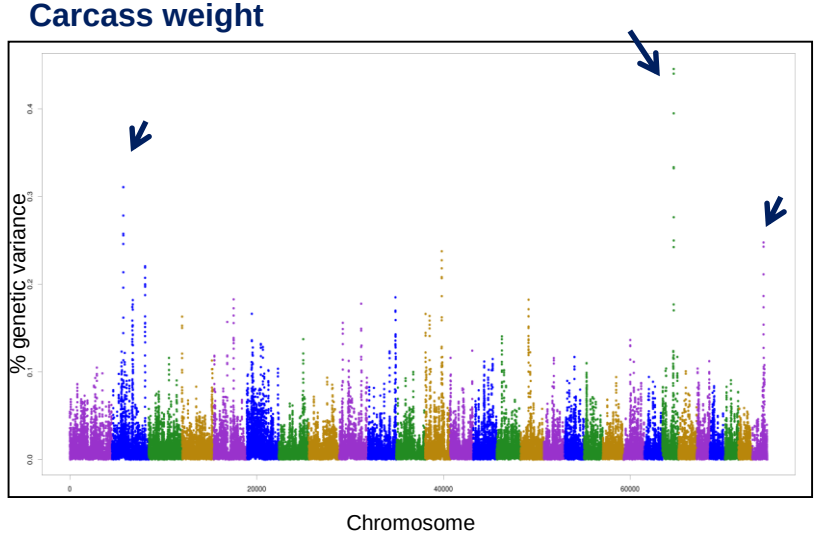
Training population

carcass and meat quality

- **Target number for 2017:**
  - 350 + 650 steers (other research projects)
- **Aims:**
  - Impact on accuracies of genomic EPDs
  - Identification of more relevant genomic regions
    - Better understanding of genetics of traits
    - Identification of markers that explain more of genetic variance
      - Smaller SNP panels (lower genotyping cost)

GBLUP 4-fold cross-validation

TRAIT	n	Accuracy
Carcass weight	510	0.39
Pistola cut	510	0.36
Rump and loin	509	0.34
IMF	486	0.30
Tenderness	506	0.32



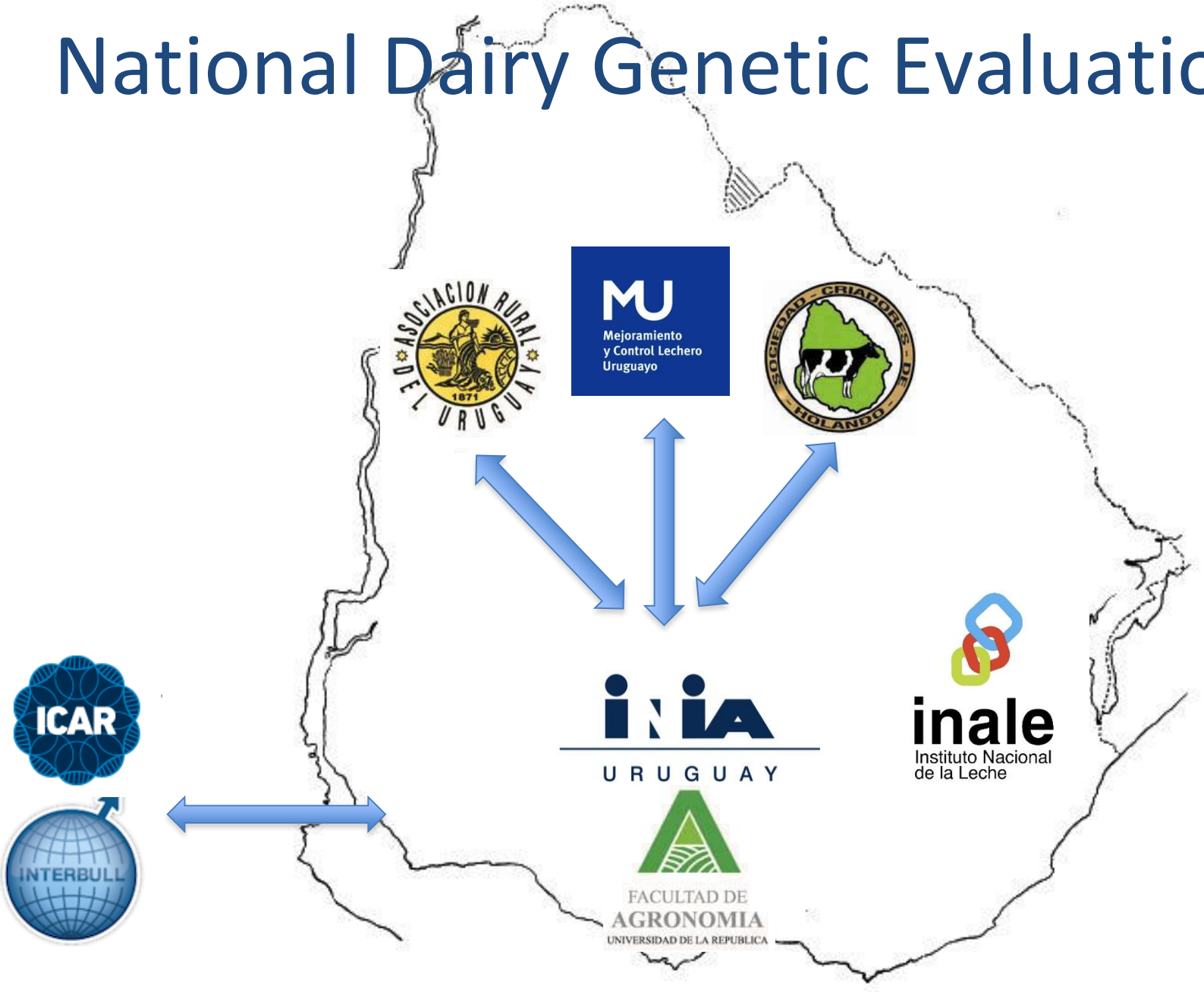
Angus breeding programme

- **Genetic evaluation system in place**
  - 120000 animals in database
  - 140 herds
  - 8000 new animals by year

- **Expected Progeny Differences of breeding animals are published and available for several relevant traits**
  - Birth, weaning and 18-month weights
  - Cow adult weight and milk
  - Eye muscle area, fat depth and intramuscular fat by ultrasound
  - Scrotal circumference

Building training populations to implement genomic selection

National Dairy Genetic Evaluation



History National Genetic Evalution

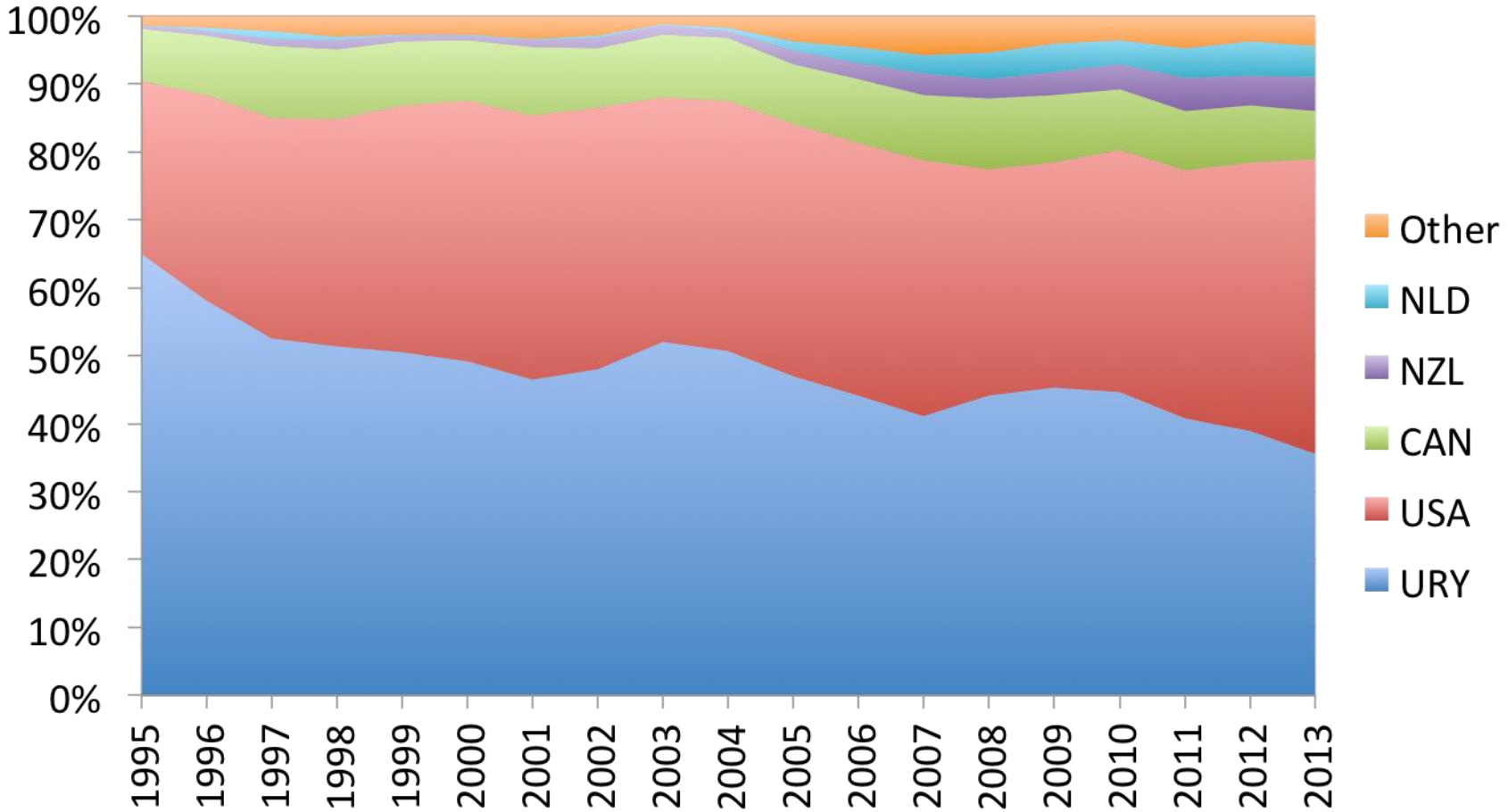
- 1994 – Productivity: Milk production (Fat)
- 1995 – Type traits
- 2003 – Productivity: fat and protein
- 2004 – Linear type traits.
- 2012
  - Selection index: IEP
  - Interbull - MACE evaluations
- 2015
  - Female fertility trait
  - Test Day Model
- 2016
  - Update IEP index (fertility)

Genetic evaluation in numbers

- **> 6.3 M** test day records
- **~ 340000** cows with records
- **~ 7400** sires with daughter (63 % domestic)

- **925** sires used by Interbull with daughter information in URY
- **85** sires with daughter information only from URY

Cow’s sire origin



Incorporation of genomic information in the Holstein national genetic evaluation

- Uruguay current situation
  - Need several years to obtain accurate genetic merit of sires (7-8 years)
  - Domestic sires (~ 30%) generally selected from parental index
  - Imported bulls: Interbull (MACE,GMACE)
  - but domestic bulls potential use genomic

Uruguayan Holstein Dairy Genetic Evaluation

- Prediction of genetic merit in Uruguayan system of production
- More than 20 years of national genetic evaluation
  - Domestic and imported parents with daughters in Uruguayans herds
  - Production and linear traits

- Base for:
  - Integration into international genetic evaluation
  - Training population for genomic selection

Training population

- Proven sires (domestic & imported)
  - limited availability of semen from historical parents
- Most recent sires
  - AI companies and breeders studs
- National Herd-Book (ARU) hair samples from parentage test
- Cows from stud and commercial herds

Training population so far

DNA / Hair samples

- **1277** animals from genetic evaluation
  - **1125** females
  - **152** sires with daughter
    - **76** domestic

- Exploring international exchange (ARG, IRL, BRA, BEL, ...)

In summary

- National genetic evaluation systems in place
- Integration of genomic information into genetic evaluations and delivering genomic proofs in some breeds
- Building training populations for genomic selection
- Undergoing development of genomic EPD for feed efficiency in beef cattle
- Expanding training population for carcass and meat quality traits


Sociedad Criadores
Merino Australiano
del Uruguay


SOCIEDAD DE CRIADORES ANGUS
URUGUAY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CORRIEDALE
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Thank you

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