A Genetic Investigation of Isle of Jersey Cattle, the Foundation of the Jersey Breed

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Objective

Compare the genetics of key Jersey bulls from Jersey Island, an isolated population for 235 years representing the foundation stock of a globally important breed.

- Population Structure
- Signatures of Selection
- Inbreeding

Jersey Breed Development

Jersey cattle were heavily exported from the Island and adapted to various climate and production systems in over 86 countries. The 24 Jersey Island farms average 122 cows per pastured-based farm in comparison to 1,125 US commercial-based farms.

Jersey Cattle (Figure 1)

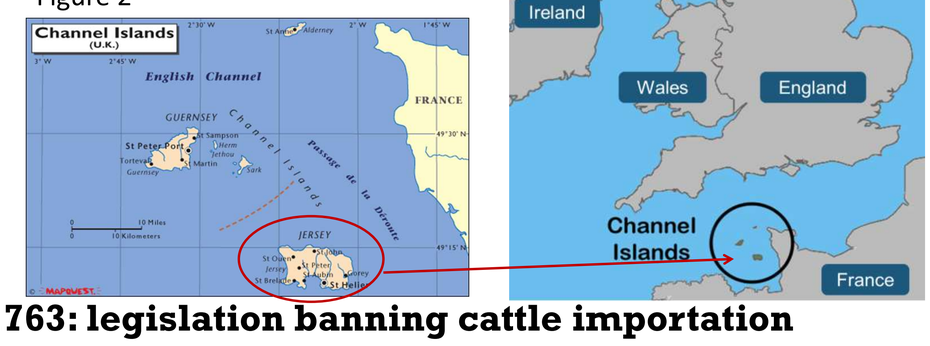
- Dairy ~15,700 lbs milk/cow
- 800-1200 lbs body weight
- 18% longer productive life than Holstein

Figure 1

Breed Origin: Jersey Island (Figure 2)

- Part of the Channel Islands
- British dependencies

Figure 2



- **1763: legislation banning cattle importation**
- 1771: cattle major product of Island (milk/butter)
- 1800's- mid 20th century: heavy exportation
- **2008: 1st genetic importation to Island in 235 years**
  - **Cryopreservation of germplasm from 400 Island bulls with the USDA-ARS National Animal Germplasm Program; Figure 3**
  - **Improve herd health & production**
  - Few voluntary "closed" herds
- 2014: 2 of 3 calves born on Island now sired by top international bull

Figure 3

Genetic Investigation

Samples

Geographic Origin	Sample Number
Isle of Jersey	49
USA Jersey	38
Canada Jersey	2*
Danish Jersey	3*
New Zealand Jersey	3*
Holstein	65
Guernsey	21
Total	**181**

Genotyping

- Illumina Bovine High-density (777K SNPs) Beadchip (Figure 4)
- 619,638 informative autosomal SNP markers

Figure 4

*Sample numbers too low to achieve statistical significance

F_{ST} Population Informative Markers

- Island Jersey compared to all other Jersey cattle (Figure 5)
- Mean = 0.056; Standard deviation = 0.054; Variance = 0.007

Figure 5

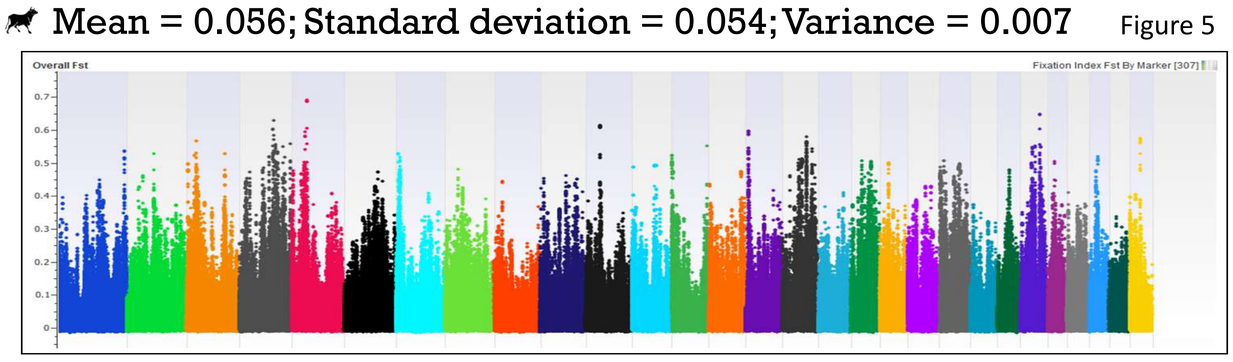


Figure 6

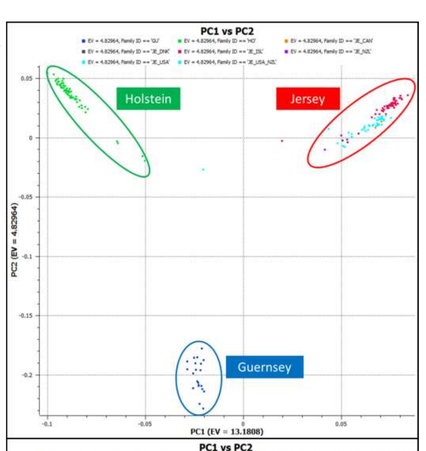
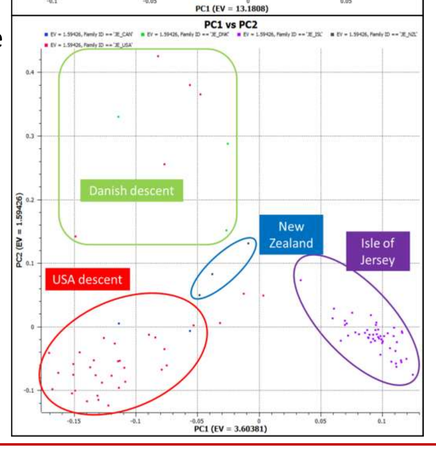


Figure 7



Population Structure

Principle Component Analysis

Figure 6

- Comparison of Jersey from multiple geographic origins to Guernsey & Holstein cattle
- Breed homogeneity of Jersey cattle when compared with other breeds

Figure 7

- Segregation of Jersey cattle correlates to geographical origin of sample individual or dominant ancestral origins as noted in pedigree analysis
- Predominant clusters are of Jersey Island or US descent
- Island and US Jersey are the primary populations in comparison for subsequent analysis

PANTHER Gene Ontology Analysis of Runs of Homozygosity (ROH)

- Most common ROH among all Jersey cattle found on Chr 7, 16, & 21

**Significant biological processes determined by PANTHER for ROH regions.

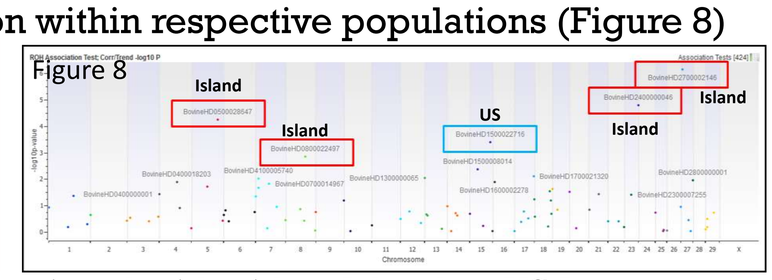
Chr 7 Biological Process	P-value
sex determination	1.41E-05
female gamete generation	1.68E-02
gamete generation	8.06E-01
Developmental process	1

Chr 16 Biological Process	P-value
protein methylation	5.60E-05
acyl-CoA metabolic process	9.88E-04
coenzyme metabolic process	2.63E-02
fatty acid metabolic process	2.00E-01

- Potential genes under selective pressure within the Jersey breed
  - Chr 7: TCF3 (sex determination)
  - Chr 16: ICMT (protein methylation)
  - Chr 16: ACOT7 (acyl-CoA metabolic process)
- ROH association test between Island and US Jersey to determine ROH potentially under selection within respective populations (Figure 8)

ROH Association		
Predictor Start SNP	Chr	P-value
BovineHD0500028647	5	5.856E-05
BovineHD0800022497	8	0.00145
BovineHD1500022716	15	0.00041
BovineHD2400000046	24	1.673E-05
BovineHD2700002146	27	7.458E-07

Figure 8



- 5 regions significantly associated with either Island or US Jersey
  - 4 within Island Jersey
  - 1 within US Jersey
- 22 candidate genes identified
  - 12 genes on Chr 5
  - 4 genes on Chr 8
  - 1 genes on Chr 24

Chr 5,8,24, 27 Biological Process	P-value
B cell mediated immunity	3.24E-04
natural killer cell activation	7.87E-04
Unclassified	1.55E-02
cellular process	4.64E-02
immune response	1.07E-01

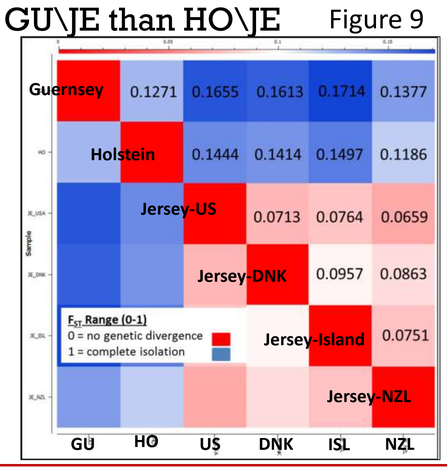
Inbreeding

*Significant difference between Island & US Jersey ***f*** statistic

Population Divergence, F_{ST}

- Greater divergence between GU\JE than HO\JE

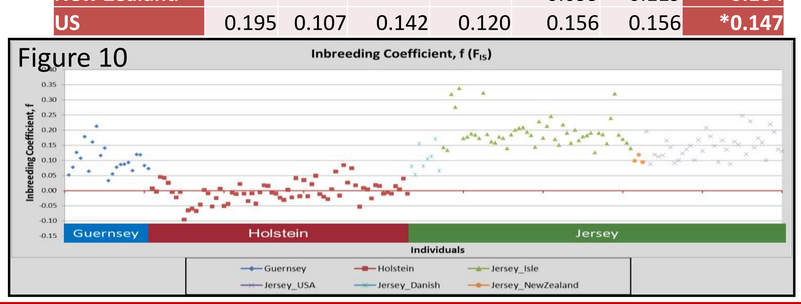
Figure 9



Inbreeding Coefficient, *f*

Population	1950	1960	1970	1980	1990	2000	Average
Guernsey					0.087	0.123	0.100
Holstein	0.013	-0.055	-0.037	-0.016	0.004	0.001	-0.004
Jersey	0.195	0.120	0.206	0.168	0.162	0.165	0.166
Danish					0.095	0.117	0.103
Isle		0.139	0.229	0.192	0.186	0.195	*0.194
New Zealand					0.099	0.119	0.104
US	0.195	0.107	0.142	0.120	0.156	0.156	*0.147

Figure 10



Conclusion: While selection & drift have separated the US and Island Jersey, they are still distinctly Jersey cattle.