



IRISH CATTLE BREEDING FEDERATION

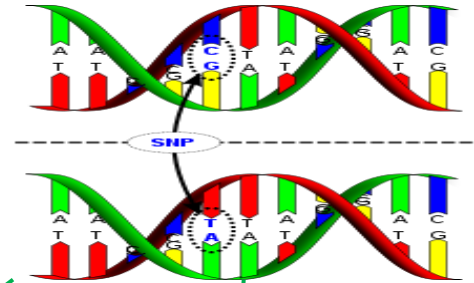
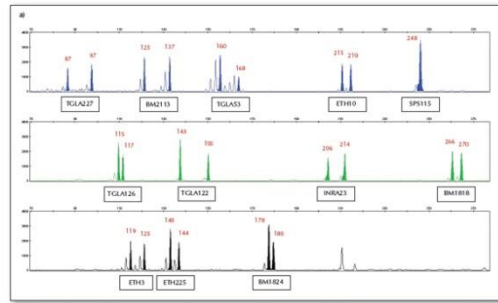
# Microsatellite Imputation for ICAR WGs: Parentage Recording and Genetic Analysis



Matthew McClure  
October 18, 2013



# Microsatellite Imputation



Infer MS from SNP Haplotype



Genotyped ONCE

# Initial Study

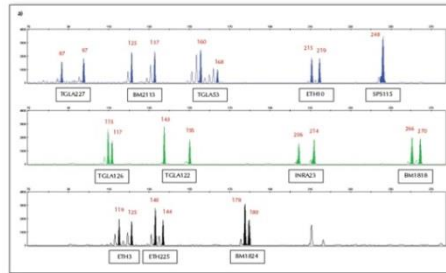


347 cattle

- ISAG bovine MS parentage panel
- Illumina HDSNP
- Phased using BEAGLE



Brown Swiss= 33



Guernsey= 16



Holstein= 250



Jersey= 48

# SNP haplotype - MS allele Associations

BM1824 Haplotype	Imputed Allele				
	Brown Swiss	Guernsey	Holstein	Jersey	Overall
BABBAABBBAAAABBBBAABABABBBBABBBAAAB	178	178	178	178	178
BAABBAABBBAAAABBBBAABABABBBBABBBAAAB			178		178
BBBBAABBBAAAABBBBAABABABBBBABBBAAAB			178		178
BABBAABBBAAAABBBBAABABABBBBAABBBBAB	178				178
BABBAABBBAAAABBBBAABABABBBBABBBAAABA	178				178
BAABBAABBBAAAABBBBAABABABABABBBAAAB		178			178
BAABABABBBAAAABBAABAABABBBBABAAAABA			180		180
BAABABABBBAAAABBAABAABABBBBABBBAAAB			180		180
AABBAABBBAAAABBAABAABABBBBABBBAAAB				180	180
AAAABAAAABBABBAAAABAABABABABAAAAAAB	180	180			180
AAAABAAAABBABBAAAABAABABABABAAAAABA	182	182	182	182	182
AAAABAAAABBABBAAAABAABABABABAAAAAAA			182		182
BAABBAABBBBABBBAAABBABABABABABAAAAA			182		182
AAAABAAAABBABBAAAABAABABABABABAAAAA			182		182
BABBAABBAABAABBBBBBBABAAABABBBBAB					
BAAABABBAABAABBBBBBBABAAABABBBBAB					
BAABAABBAABAABBBBBBBABAAABABBBBAB					
AABBAABBAABAABBBBBBBABAAABABBBBAB	188				188
AAAABABBAABAABBBBBBBABAAABABBBBAB	188				188



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## Imputation of microsatellite alleles from dense SNP genotypes for parental verification

*Matthew McClure<sup>1</sup>, Tad Sonstegard<sup>1</sup>, George Wiggins<sup>2</sup> and Curtis P Van Tassel<sup>1\*</sup>*

<sup>1</sup> Bovine Functional Genomics Lab, United States Department of Agriculture, Agriculture Research Service, Beltsville, MD, USA  
<sup>2</sup> Animal Improvement Program Lab, United States Department of Agriculture, Agriculture Research Service, Beltsville, MD, USA

17% MS-SNP haplotypes identical across  $\geq 2$  breeds



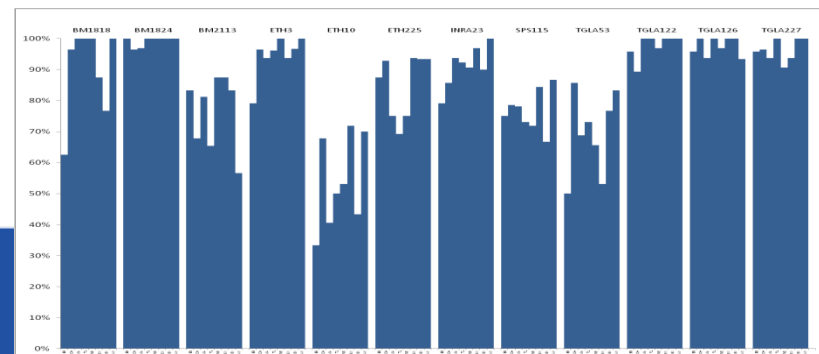
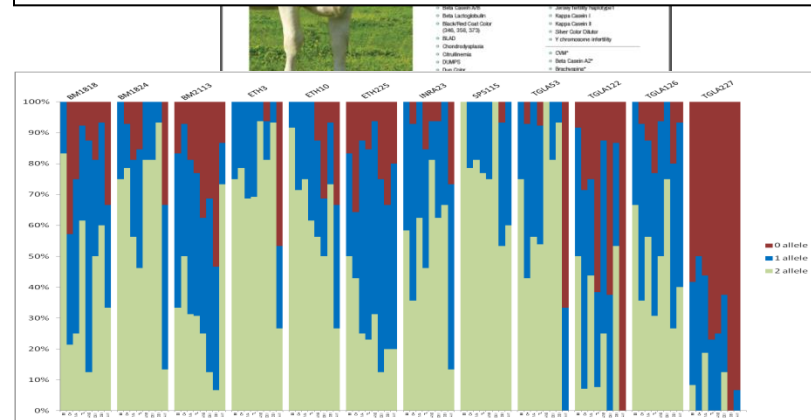


# Beef Application



~77% had imputed alleles  
~86% Concordance

- 8 beef breeds: 116 animals
  - Beagle phased
  - Vlookup for MS
- Belgian Blue
- Charolais
- Maine-Anjou
- Texas Longhorn
- Ankole-Watusi
- Angus
- Devon
- Dexter



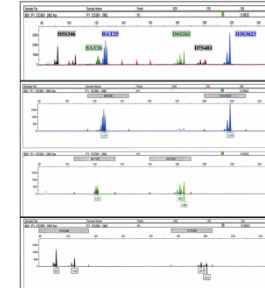
# Microsatellite Imputation

Initial reference population: SNP + ISAG MS genotypes

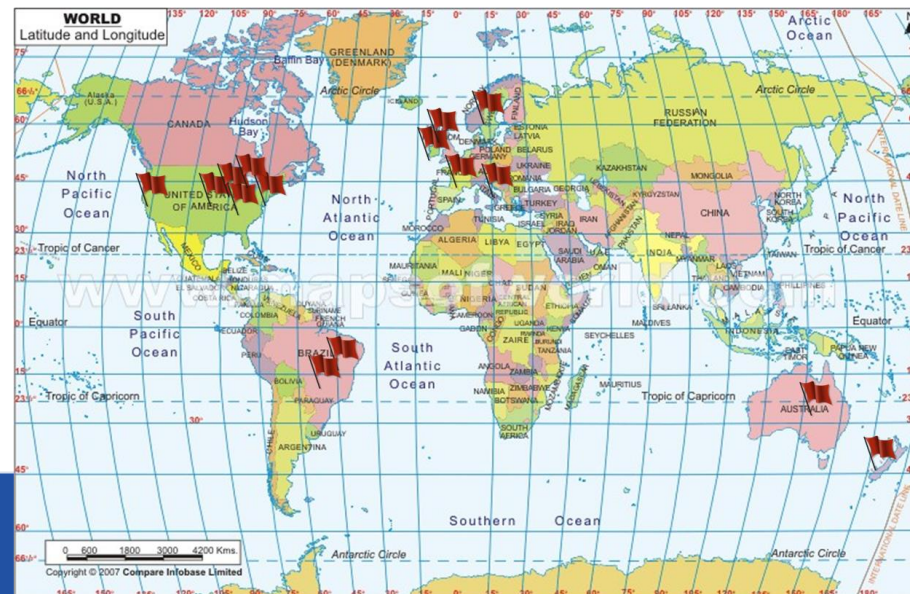
7,076 *Bos taurus*

1,008 *B. indicus*

39 pure breeds



*B. taurus*: 1,463 to 7,069 animals per MS



Breed	SNP	SNP+MS
Abundance	172	165
Angus	623	235
Aubrac	239	234
Ayshire	523	86
Bazadaise	80	53
Beefmaster	36	36
Belmont Red	40	
Belgian Blue	210	12
Blonde D'Aquitain	225	201
Brahman	410	364
Brangus	13	13
Braunvieh	17	17
Bretonne Pie Noire	27	16
Brown Swiss	91	64
Brune Des Alpes	109	109
Charolais	1449	1109
Chiangus	19	0
Crossbred	506	3
Devon	16	16
Dexter	15	15
Fresian	163	35
Gasconne	142	142
Gelbvieh	44	0
Gir	209	101
Guernsey	110	18
Hereford	853	243
Holstein	2596	678
Jersey	87	131
Kerry	1	0
Limousin	2171	1572
Longhorn	13	13
Maine Anjou	38	16
Montbéliarde	257	251
Murray Grey	22	
N'Dama	24	0
Nelore	2659	135
Normande	256	242
Parthenaise	291	218
Pie Rouge Des Plaines	160	116
Piedmontese	24	17
Red Angus	61	47
Red Pie (italia)	2	0
Romagnola	23	23
Rouge Flamande	41	41
Salers	258	234
Santa Gertrudis	99	0
Sheko	18	0
Shorthorn	188	0
Simmental	907	324
Swedish Red	12	9
Tarentaise	167	155
Tropical Composite		336
Vosgienne	53	49
Watusi	15	15
<b>TOTAL</b>	<b>17138</b>	<b>8259</b>

# Haplotype Selection:



1: Haplotypes centered on MS



2:  $\geq 4$  SNP-MS haplotype count

3: Haplotype is associated with 1 MS  $\geq 90\%$

4: Maximize # animals selected



A: Increase haplotype if  $>1\%$  animals selected



Per MS: ~780 haplotypes,  
~70 SNP per haplotype (1,088 total)

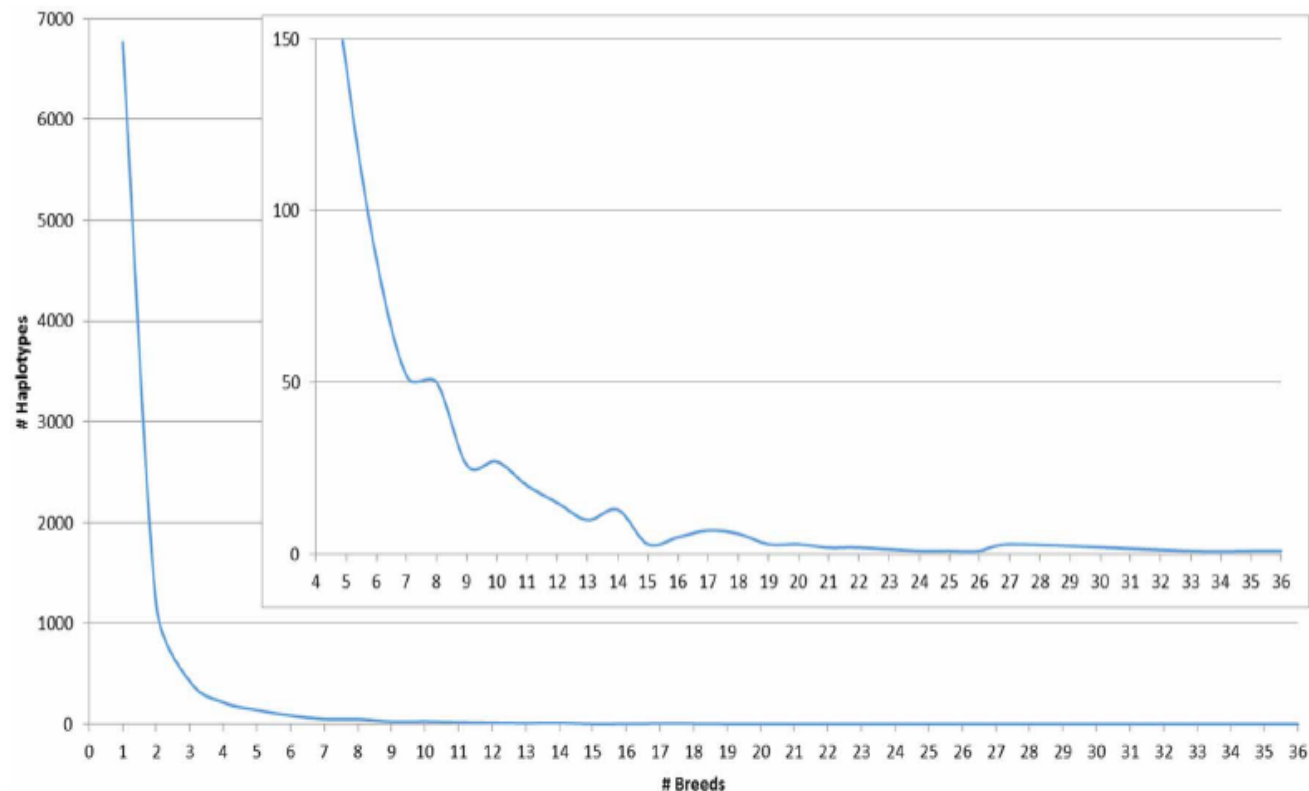


FIGURE 1 | Count of MS-SNP haplotypes present in at least one breed across the whole reference population.



# Microsatellite Imputation

Initial reference population: SNP + ISAG MS genotypes

7,076 *Bos taurus*

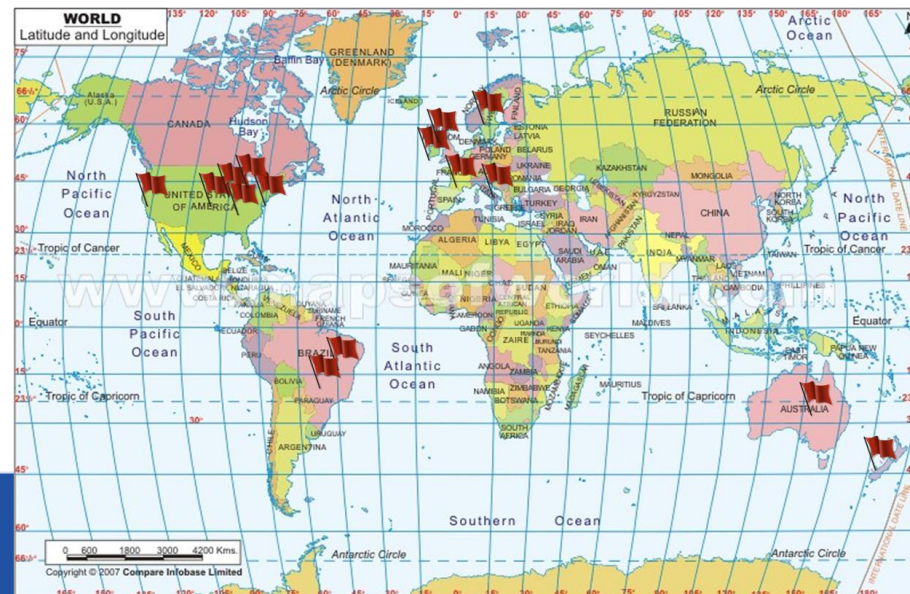
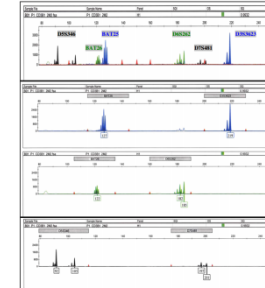
1,008 *B. indicus*

39 pure breeds

Initial validation population: SNP genotypes

8,622 *Bos taurus* & *B. indicus* animals

45 pure breeds, some crossbreds



Breed	SNP	SNP+MS
Abundance	172	165
Angus	623	235
Aubrac	239	234
Ayshire	523	86
Bazadaise	80	53
Beefmaster	36	36
Belmont Red	40	
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<b>TOTAL</b>	<b>17138</b>	<b>8259</b>

# MS Accuracy: Parental Validation

1 MS conflict allowed



Validation Population

(N=1287)

90.55%

Discovery Population

(N=3470)

96.47%

# Microsatellite Imputation -Beagle used

**IDB SNP CHIP**  
INTERNATIONAL DAIRY & BEEF  
SNP CHIP

GeneSeek® Genomic Profiler™  
One Sample, One Simple, Comprehensive Solution

Developed in association with the Irish Cattle Breeding Federation (ICBF), Teagasc, Weatherbys and USDA's Agricultural Research Service

This custom chip is the very latest design catering for both Beef and Dairy. The chip consists of the Illumina® Infinium® array (50K) and 100K SNP arrays. It is designed to ensure very high imputation accuracy in 100% of the available data for genotyping purposes. The only panel of SNPs provides the very latest data product for both Beef & Dairy breeds.

For more details Contact: Weatherbys Ireland DNA Laboratory  
+353(0)45875521  
jflinn@weatherbys.ie

PHASE

↓



BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL	BovineHL
B	A	B	B	A	B	B	A	A	A	B	B	A	B	A	A		
B	A	B	B	B	B	B	B	A	A	B	B	B	A	B	B	B	B

Haplotype	Angus	Ayshire	BelgianBlue	Charolais	Guernsey	Hertford	Holstein	Jersey	Limousin	RedAngus	Shorthorn	Simmental	Overall
AAABBBAAABBAABBBBAAABBAABBA/		266	266	266		266			266	266	266	266	266
BBBBBAAAABBAABBBBAAABBAABBA/													262
AABBBBAAAABBAABAAAABBAABAAA/							270						270
BBBBBAAAABBAABBBBAAABBAABBA/								262					262
AABBABAABBAABBBBAAABBAABBA/					280					280			280
AABBBBABAABBAABAAAABBAABAAA/													286
AABBBBABAABBAABAAAABBAABAAA/												268	268
AABBABAABBAABBBBAAABBAABBA/						262							262
AABBABAABBAABBBBAAABBAABBA/													268
BBBBBAAAABBAABBBBAAABBAABBA/				272				272					272
AABBABAABBAABBBBAAABBAABBA/		260											260
AABBBBABAABBAABAAAABBAABAAA/										260			260
AAABBAABBAABBBBAAABBAABBA/				268					268			268	268
AAARRRRARRRRAAAAAARRRRA/	262										262	262	262
AABBABAABBAABBBBAAABBAABBA/	258	258		258							258		258
AAABBAABBAABBBBAAABBAABBA/	266		266			266	266						266
AAABBAABBAABBBBAAABBAABBA/				268									
AAABBAABBAABBBBAAABBAABBA/							262						
AABBBBABAABBAABAAAABBAABBA/				266									
AABBBBABAABBAABAAAABBAABBA/						266							

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Imputation of microsatellite alleles from dense SNP genotypes for parentage verification across multiple *Bos taurus* and *Bos indicus* breeds

Matthew C. McClure<sup>1\*</sup>, Tad S. Sonstegard<sup>1</sup>, George R. Wiggans<sup>2</sup>, Alison L. Van Eenennaam<sup>3</sup>, Kristina L. Weber<sup>3</sup>, Cecilia T. Penedo<sup>4</sup>, Donagh P. Berry<sup>5</sup>, John Flynn<sup>6</sup>, Jose F. Garcia<sup>7</sup>, Adriana S. Carmo<sup>8</sup>, Luciana C. A. Regitano<sup>9</sup>, Milla Albuquerque<sup>10</sup>, Marcos V. G. B. Silva<sup>11</sup>, Marco A. Machado<sup>11</sup>, Mike Coffey<sup>12</sup>, Kirsty Moore<sup>12</sup>, Marie-Yvonne Boscher<sup>13</sup>, Lucie Genestout<sup>13</sup>, Raffaele Mazza<sup>14</sup>, Jeremy F. Taylor<sup>15</sup>, Robert D. Schnabel<sup>15</sup>, Barry Simpson<sup>16</sup>, Elisa Marques<sup>16</sup>, John C. McEwan<sup>17</sup>, Andrew Cromie<sup>18</sup>, Luiz L. Coutinho<sup>19</sup>, Larry A. Kuehn<sup>20</sup>, John W. Keele<sup>20</sup>, Emily K. Piper<sup>21</sup>, Jim Cook<sup>22</sup>, Robert Williams<sup>23</sup>, Bovine HapMap Consortium and Curtis P. Van Tassell<sup>1</sup>

# Irish Parent Verification Process



Herdbook

Certificate Issued

Rules Applied

Calf

Test against all Sires in DB

Verified

2000 SNP shared:

3K, LD, 50K, HD, IDB

Failed

SNP - Sire Check

Verified

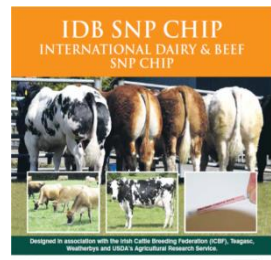
ISAG 120 SNP

ICBF Database

Weatherbys

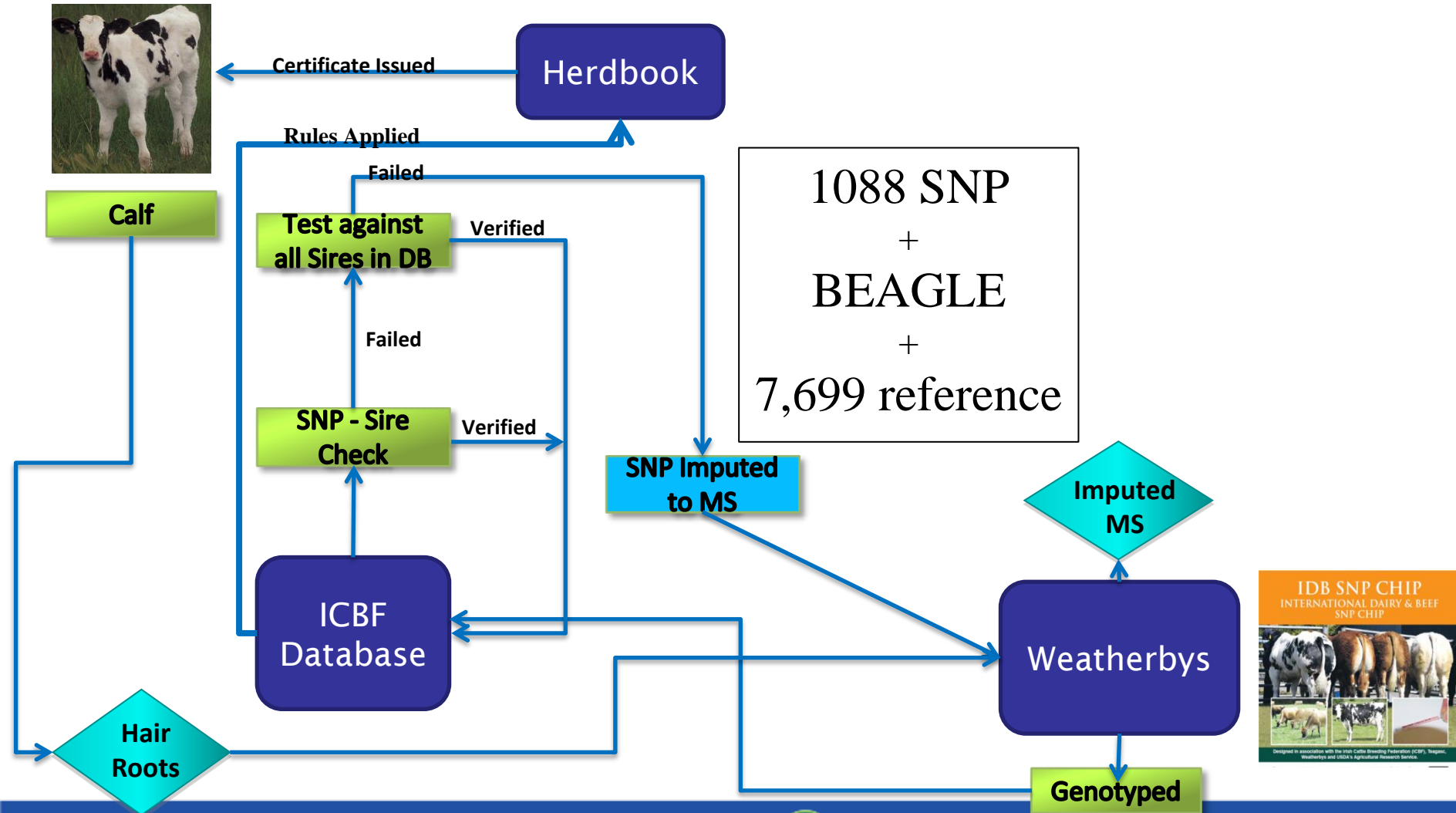
Genotyped

Hair Roots

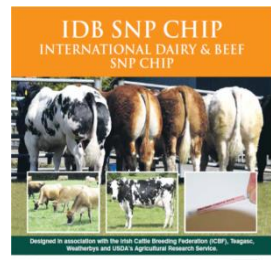
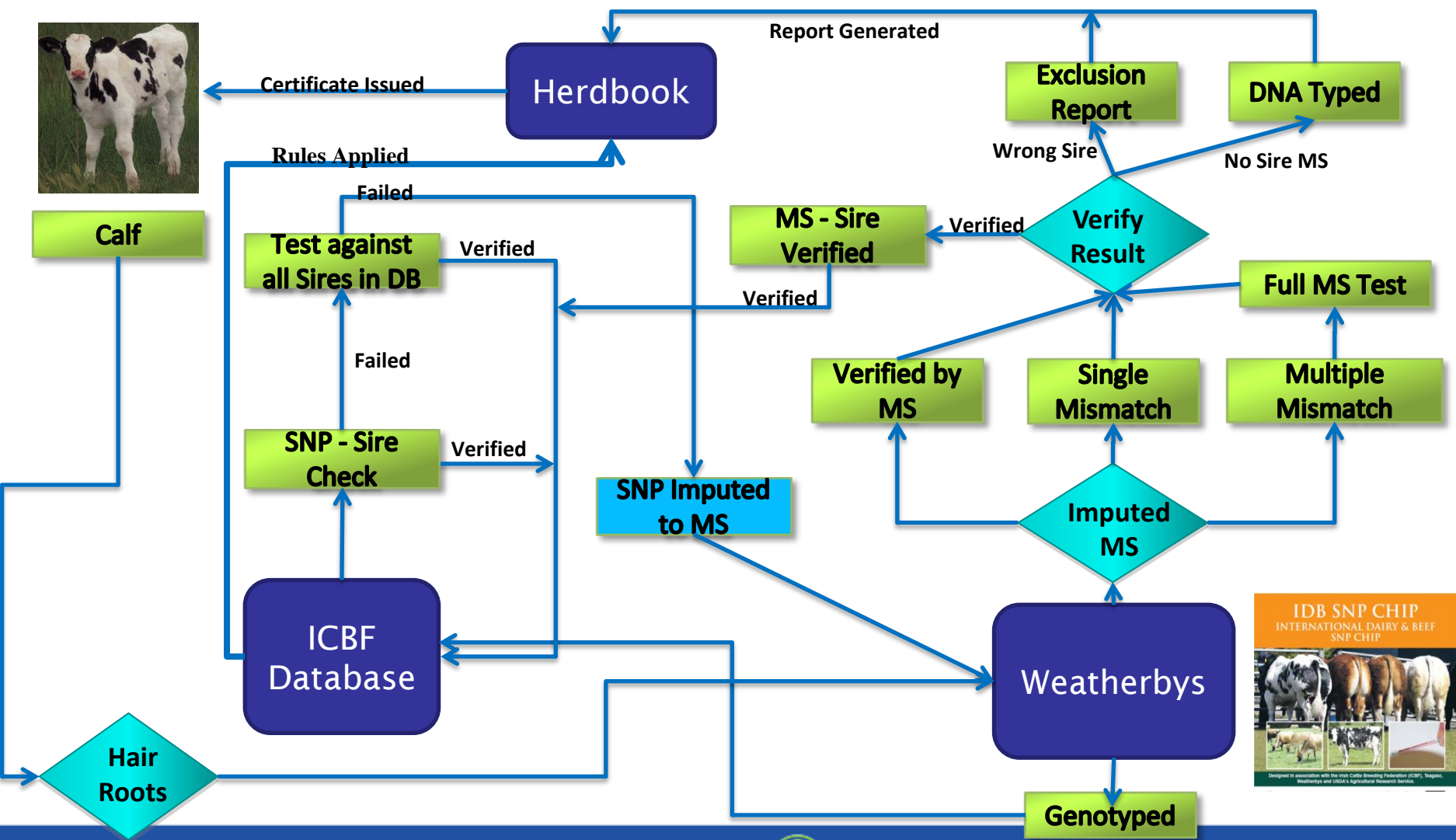




# Irish Parent Verification Process



# Irish Parent Verification Process

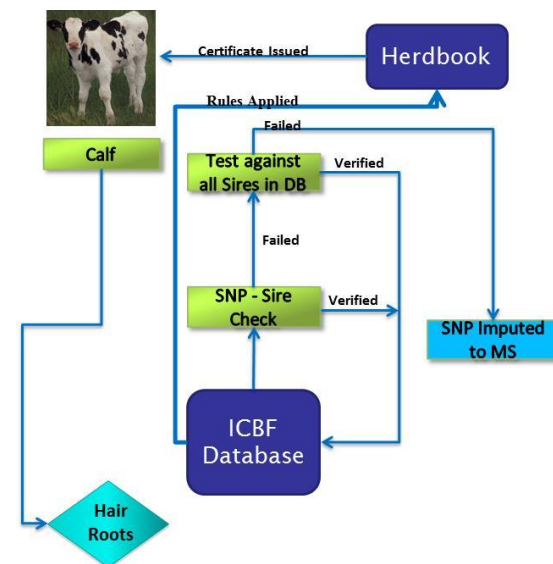


# Genotyping –Irish status for 2013

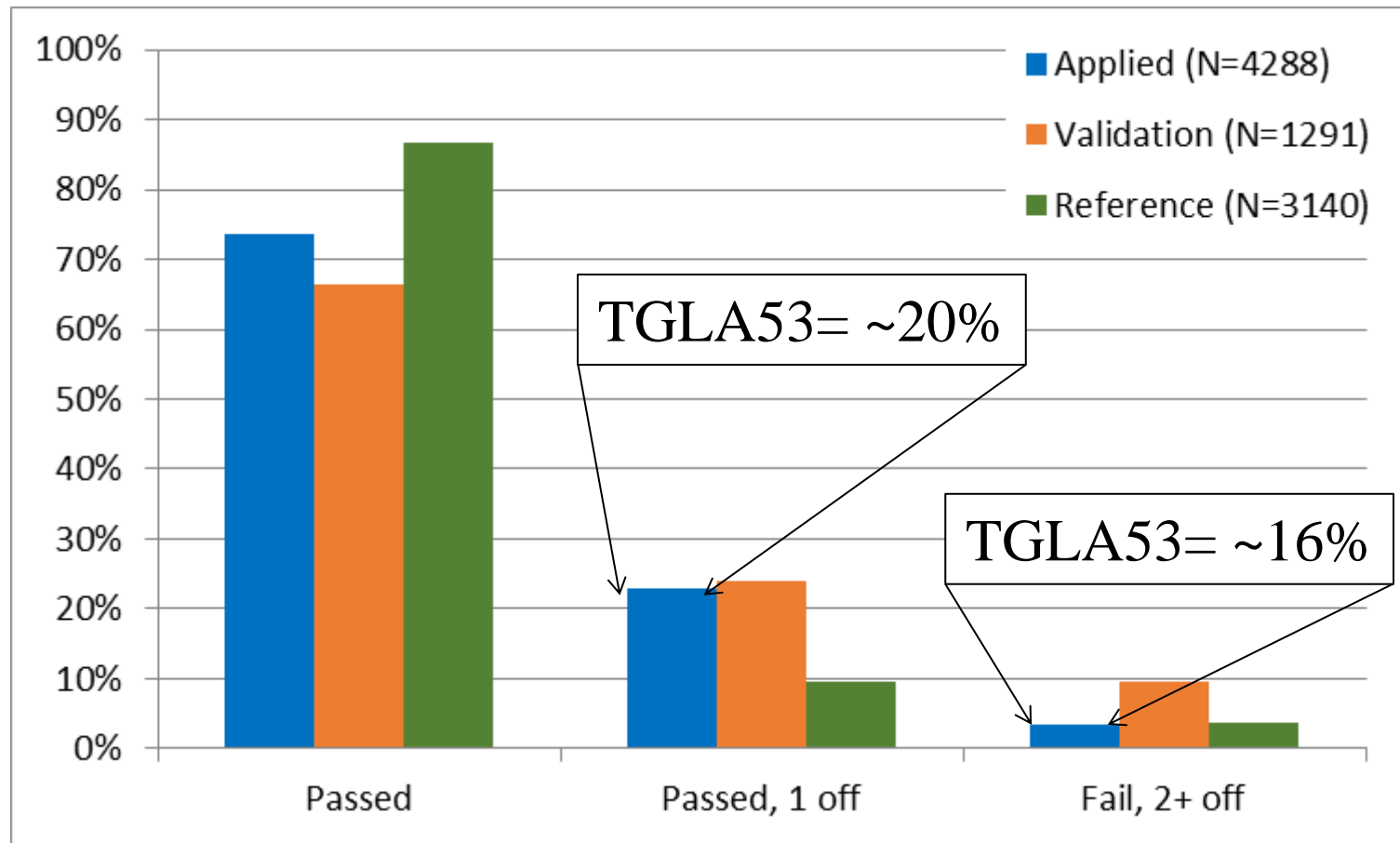


- ~16,680 Animals genotyped
  - ~5,600 Beef Animals
  - ~750 failed genotyped: Call Rate <0.90

- Sire Verification within breed
  - By SNP: 48% to 10%
  - By Microsatellite: 60% to 20%
  - Remaining are 'Typed'



# Imputation Accuracy for Parentage Verification



Applied: ICBF imputed MS genotypes. Reference: McClure et al. 2013's imputed MS genotype.

Validation: McClure et al. 2013's traditional MS genotype

Passed: no marker conflicts. Passed -1 off: 1 marker conflict occurred. Fail:  $\geq 2$  marker conflicts exist.



# Impact of Microsatellite Imputation

- 4,952 Irish animals have had microsatellite genotypes imputed (October, 2013) as:
  - SNP parentage failed (small #)
  - Embryo transfer animal
  - No SNP genotype on sire (most of them)
- >96% accuracy with imputed microsatellites
  - Accuracy will increase for new runs
  - >97% accuracy without TGLA53
- Microsatellite imputation has saved Irish cattle farmers ~€95,000, as cost of MS genotyping is ~€20/animal.

# Thank you

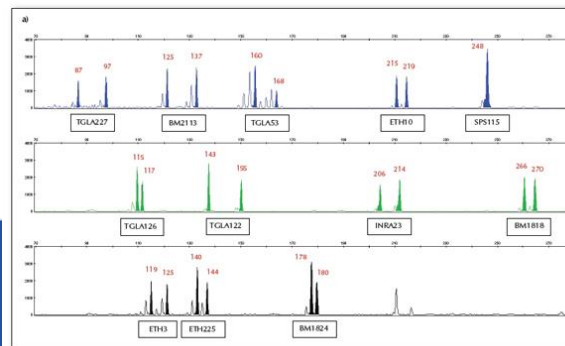


<1990's

Recipient's blood			Reactions with donor's red blood cells			
ABO antigens	ABO antibodies	ABO blood type	Donor type O cells	Donor type A cells	Donor type B cells	Donor type AB cells
None	Anti-A Anti-B	O				
A	Anti-B	A				
B	Anti-A	B				
A & B	None	AB				

Compatible     
 Not compatible

Present



Future

