

Genomic selection at CRV



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Head Breeding & Support



This talk

- History
- EuroGenomics
- Combining SNP chips
- Breeding program
- National genetic evaluation
- New traits
- Multi-breed



History

- 1990s: QTL mapping & marker-assisted selection
 - ▶ too few markers, QTL have too small effect
- 2001: GS theory by Meuwissen, Hayes & Goddard
 - ▶ too few markers available, too expensive
- 2006: GS using 3,000 SNPs
 - ▶ need more markers
- 2007: GS using 50,000 SNPs
 - ▶ need more reference bulls
- 2008: 1,500 → 4,000 bulls
- 2009: 4,000 → 16,000 bulls (EuroGenomics)

EuroGenomics



■ European partners

- ▶ CRV Nld/Bel
- ▶ VIT/DHV Deu
- ▶ UNCEIA Fra
- ▶ Viking Genetics Dnk/Swe/Fin

■ World's largest reference population

- ▶ 18,300 progeny tested bulls
- ▶ 5-15% increase in reliability

■ Joint R&D and SNP chip ordering



Combining SNP chips

- CRV custom 50K chip, others BovineSNP50
 - ▶ 20K in common → 'impute' missing 30K
- 1000 key sires 2x genotyped
- Imputation by Tom Druet (U of Liege)
- CRV 50K → BovineSNP50 <1% errors



Combining SNP chips

- CRV custom 50K chip, others BovineSNP50
 - ▶ 20K in common → 'impute' missing 30K
- 1000 key sires 2x genotyped
- Imputation by Tom Druet (U of Liege)
- CRV 50K → BovineSNP50 <1% errors
- 3K → 50K ~3% errors
 - ▶ some loss in reliability
- 50K → 777K <1% errors
 - ▶ 600 key sires 2x genotyped



Breeding program

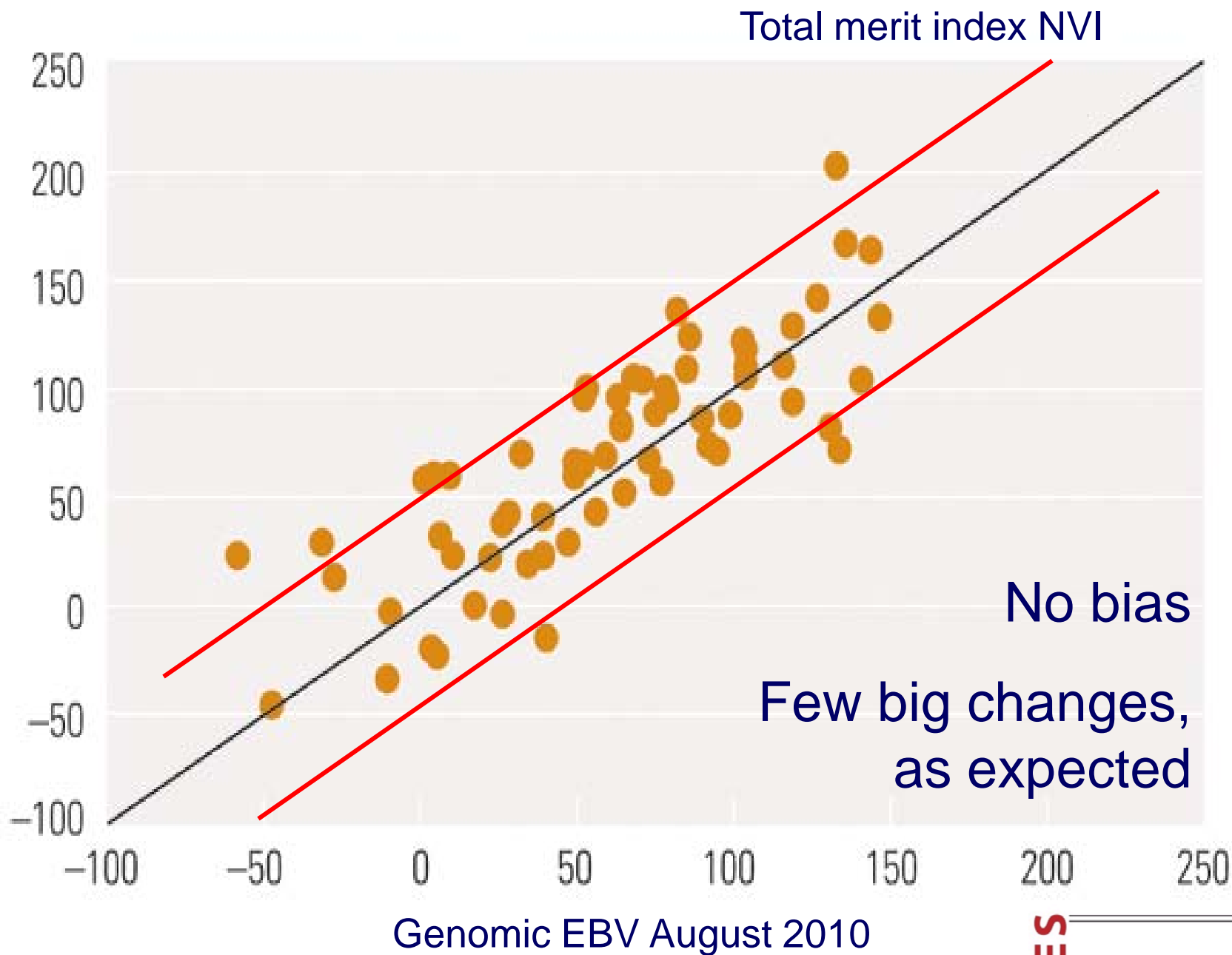


- Selection intensity ↑ generation interval ↓
- 2600 bulls genotyped, 170 progeny tested (1:15)
 - ▶ 100 Black-and-white NLD, BEL
 - ▶ 40 Red-and-white NLD, BEL
 - ▶ 30 Black-and-white USA, CZE
- Large embryo program
 - ▶ sell >4000 embryo's with buy-back contract
 - ▶ from nucleus and breeders
- Large scale genotyping to find elite bull dams
- >50% use of young mating sires

National evaluation

- 1st official release genomic EBVs in August 2010
- Combines direct genomic EBV & traditional EBV
 - ▶ cows : $GEBV = DGV \& EBV$
 - ▶ heifers : $GEBV = DGV \& \text{parent average}$
 - ▶ proven bulls : $GEBV = DGV \& EBV$
 - ▶ young bulls : $GEBV = DGV \& \text{pedigree index}$
- Young bull GEBV not biased due to dam info

Daughter-based EBV December 2010



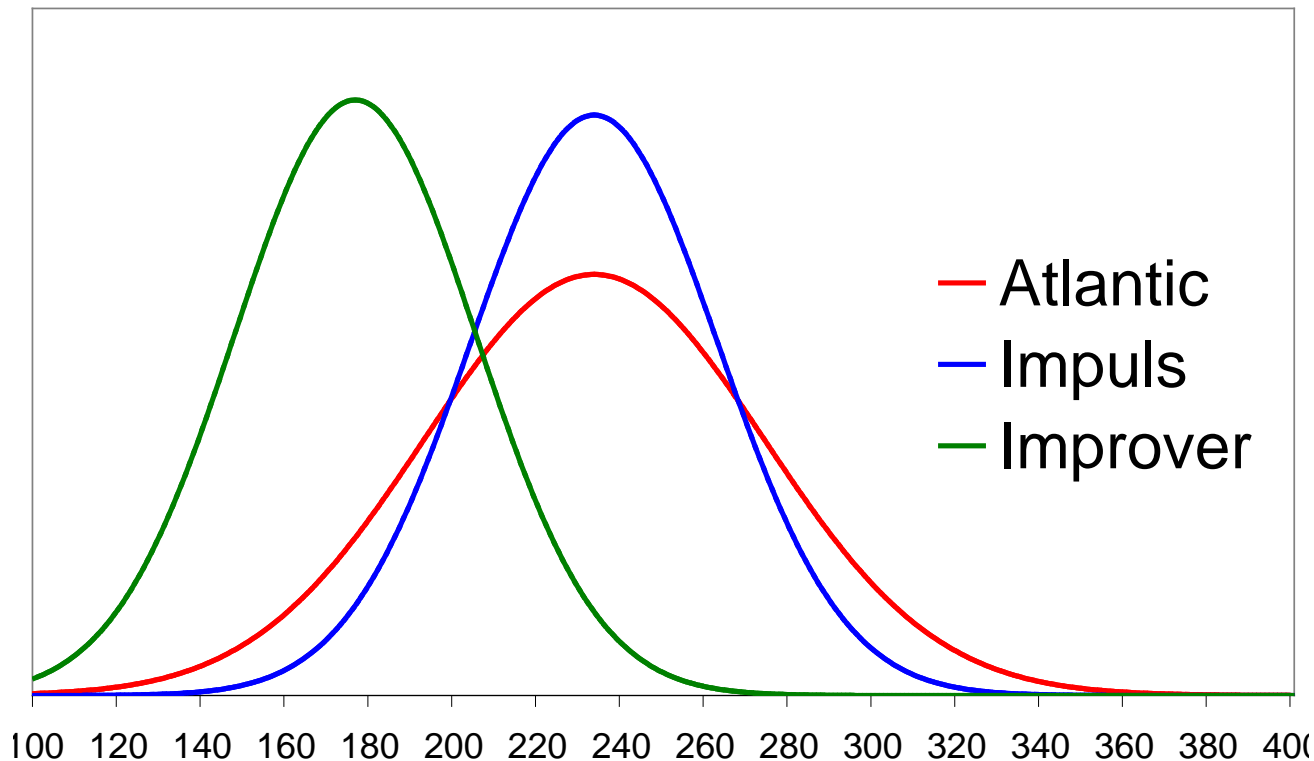
Perspublicatie stierindexen Zwartbont

augustus 2010

| Ki | Stiernaam | Vader | M-vader | B | Bt | NVI | +/- | dtrs | Bt | kgM | %V | %E | kgV | kgE | INET | +/- | Bt | Lvd | Cgt | Vru | Bt | F | R | U | B | Ext |
|----------------|---------------------------|-----------|-------------|------|-----|------|-----|------|-----------|-------|-------|-------|-----|-----|------|-----|-------------|------|-----|-----|-----------|-----|-----|-----|-----|-----|
| Zwartbontbasis | | | | | pnt | | | | Productie | | | | | € | | | Functioneel | | | | Exterieur | | | | | |
| CRV | De Biesheuvel Sunrise | Jardin | O Man | GfW | 59 | +236 | n | 0 | 66 | +869 | -0.11 | +0.19 | +27 | +47 | +164 | n | 49 | +328 | 102 | 101 | 57 | 106 | 103 | 108 | 104 | 109 |
| CRV | Voudhoeve 1042 Impuls | O Man | Jesther | Gnat | 80 | +233 | +27 | 100 | 90 | +1164 | +0.01 | +0.11 | +51 | +50 | +176 | +9 | 61 | +424 | 107 | 100 | 83 | 108 | 107 | 103 | 102 | 106 |
| CRV | Delta Atlantic | Ramos | O Man | GfW | 60 | +233 | n | 0 | 66 | +977 | -0.25 | -0.03 | +19 | +31 | +85 | n | 53 | +737 | 110 | 103 | 58 | 104 | 104 | 104 | 104 | 106 |
| CRV | Veneriete 252 Tempo | Goldwyn | O Man | GfW | 60 | +229 | n | 0 | 66 | +536 | +0.28 | +0.11 | +48 | +28 | +119 | n | 52 | +500 | 110 | 103 | 58 | 106 | 103 | 106 | 101 | 106 |
| CRV | Ludiek Bluejag | Bertil | O Man | GfW | 59 | +223 | n | 0 | 66 | +839 | -0.06 | +0.10 | +31 | +38 | +131 | n | 49 | +308 | 106 | 100 | 57 | 104 | 104 | 110 | 106 | 110 |
| CRV | Delta Content | Bertil | Ramos | GfW | 59 | +222 | n | 0 | 66 | -151 | +0.41 | +0.32 | +27 | +21 | +116 | n | 49 | +359 | 109 | 101 | 57 | 99 | 102 | 107 | 107 | 107 |
| CRV | Timmer Tyson | O Man | Novalis | Gnat | 84 | +221 | +2 | 115 | 92 | -81 | +0.85 | +0.34 | +66 | +25 | +156 | +4 | 67 | +276 | 107 | 105 | 88 | 96 | 103 | 98 | 104 | 99 |
| CRV | Delta Emerald | Goldwyn | O Man | GfW | 60 | +220 | n | 0 | 66 | +1038 | -0.06 | +0.04 | +39 | +39 | +129 | n | 52 | +419 | 108 | 99 | 58 | 108 | 106 | 110 | 103 | 110 |
| CRV | Delta Brilliant | Goldwyn | O Man | GfW | 60 | +215 | n | 0 | 66 | +996 | +0.06 | -0.02 | +48 | +36 | +125 | n | 52 | +467 | 105 | 100 | 58 | 105 | 106 | 107 | 104 | 108 |
| CRV | Newhouse Gofast | Goldwyn | O Man | GfW | 60 | +215 | n | 0 | 66 | +914 | -0.04 | -0.02 | +36 | +30 | +96 | n | 52 | +554 | 106 | 100 | 58 | 110 | 104 | 109 | 105 | 111 |
| CRV | Delta Bonanza | Bertil | Ramos | GfW | 59 | +214 | n | 0 | 66 | -155 | +0.49 | +0.39 | +33 | +26 | +142 | n | 49 | +299 | 106 | 101 | 57 | 102 | 106 | 104 | 106 | 106 |
| CRV | Skalsumer Blitz | Paramount | O Man | GfW | 60 | +212 | n | 0 | 66 | +1945 | -0.32 | -0.12 | +51 | +55 | +150 | n | 53 | +463 | 107 | 96 | 58 | 100 | 101 | 103 | 108 | 105 |
| CRV | Mag Yard Aswin | Goldwyn | Ramos | GfW | 60 | +212 | n | 0 | 66 | -77 | +0.16 | +0.13 | +10 | +8 | +45 | n | 52 | +675 | 110 | 103 | 58 | 108 | 105 | 109 | 104 | 110 |
| CRV | Delta Oviedo | Masool | O Man | GfW | 60 | +211 | n | 0 | 66 | +480 | +0.08 | +0.13 | +28 | +28 | +108 | n | 52 | +453 | 109 | 101 | 58 | 101 | 101 | 107 | 103 | 106 |
| CRV | Delta Booster | Bertil | O Man | GfW | 59 | +209 | n | 0 | 66 | +1070 | -0.10 | +0.14 | +37 | +50 | +172 | n | 49 | +254 | 105 | 100 | 57 | 99 | 101 | 103 | 103 | 103 |
| CRV | Tollebeke Epic | Goldwyn | O Man | GfW | 60 | +209 | n | 0 | 66 | +310 | +0.31 | +0.14 | +40 | +23 | +106 | n | 52 | +484 | 108 | 102 | 58 | 107 | 104 | 108 | 100 | 107 |
| CRV | Delta Stan | Goldwyn | Shuttle | GfW | 60 | +207 | n | 0 | 66 | -720 | -0.01 | -0.10 | +22 | +16 | +46 | n | 51 | +659 | 109 | 99 | 58 | 111 | 109 | 115 | 105 | 115 |
| CRV | Delta Astro | Goldwyn | | | | | | | | | | | | | | | | | | | | | | | | 104 |
| CRV | Delta Bilbao | Goldwyn | | | | | | | | | | | | | | | | | | | | | | | | 103 |
| CRV | Midwolder Goldmar | Goldwyn | | | | | | | | | | | | | | | | | | | | | | | | 104 |
| CRV | Newhouse Valor | Ramos | | | | | | | | | | | | | | | | | | | | | | | | 102 |
| CRV | Ralma O-Man Cf Cricket-Et | O Man | | | | | | | | | | | | | | | | | | | | | | | | 104 |
| CRV | Etazon Stefano | Goldwyn | | | | | | | | | | | | | | | | | | | | | | | | 103 |
| CRV | Timmer Davis | Roumare | | | | | | | | | | | | | | | | | | | | | | | | 103 |
| CRV | Delta Arrogo | Spencer | | | | | | | | | | | | | | | | | | | | | | | | 102 |
| CRV | Delta Belfast | Ramos | | | | | | | | | | | | | | | | | | | | | | | | 108 |
| CRV | Delta Alejandro | Bertil | | | | | | | | | | | | | | | | | | | | | | | | 106 |
| CRV | Blom Farm Award | Ramos | | | | | | | | | | | | | | | | | | | | | | | | 104 |
| CRV | De Biesheuvel Bertoli | Bertil | O Man | GfW | 59 | +199 | n | 0 | 66 | +636 | +0.06 | +0.21 | +37 | +43 | +169 | n | 49 | +330 | 106 | 99 | 57 | 104 | 100 | 104 | 105 | 106 |
| CRV | Southland Bronco | Stylist | O Man | GfW | 55 | +193 | n | 0 | 63 | +170 | +0.58 | +0.33 | +56 | +34 | +172 | n | 46 | +121 | 98 | 98 | 54 | 103 | 98 | 107 | 106 | 107 |
| CRV | Delta Wanted | Goldwyn | Ramos | GfW | 60 | +193 | n | 0 | 66 | +547 | +0.12 | -0.07 | +34 | +13 | +46 | n | 52 | +721 | 110 | 100 | 58 | 107 | 106 | 107 | 105 | 109 |
| CRV | Delta Benedict | Picky | O Man | GfW | 59 | +192 | n | 0 | 66 | +72 | +0.56 | +0.19 | +50 | +18 | +106 | n | 51 | +392 | 105 | 102 | 58 | 103 | 101 | 104 | 104 | 105 |
| CRV | Aurora Jeroen | Bertil | O Man | GfW | 59 | +191 | n | 0 | 66 | +455 | +0.46 | +0.19 | +60 | +32 | +149 | n | 49 | +220 | 106 | 101 | 57 | 101 | 106 | 102 | 103 | 103 |
| CRV | Delta Mica | Shuttle | Harry | GfW | 60 | +191 | n | 0 | 66 | +1232 | +0.04 | +0.00 | +57 | +42 | +142 | n | 52 | +453 | 106 | 95 | 58 | 101 | 103 | 107 | 103 | 106 |
| CRV | Delta Augustus | Gibor | Masool | GfW | 58 | +191 | n | 0 | 65 | +605 | -0.24 | -0.01 | +5 | +20 | +51 | n | 49 | +685 | 106 | 102 | 56 | 98 | 101 | 105 | 105 | 104 |
| CRV | Delta Auckland | Ramos | O Man | GfW | 60 | +191 | n | 0 | 66 | +262 | +0.17 | -0.01 | +26 | +8 | +36 | n | 53 | +704 | 109 | 102 | 58 | 105 | 108 | 106 | 105 | 108 |
| CRV | Goolstar Diamond | Jocko | Willis | Gnat | 87 | +190 | +17 | 174 | 95 | +487 | +0.36 | +0.12 | +52 | +27 | +121 | +7 | 71 | +457 | 105 | 96 | 90 | 98 | 105 | 108 | 105 | 107 |
| CRV | Delta Trinity | Masool | O Man | GfW | 60 | +189 | n | 0 | 66 | +911 | +0.12 | +0.05 | +50 | +36 | +132 | n | 52 | +334 | 103 | 100 | 58 | 104 | 101 | 104 | 104 | 105 |
| CRV | Dudam Surprise | Dustin | Luxemburg | Gnat | 91 | +187 | +2 | 211 | 97 | +537 | -0.02 | +0.06 | +21 | +24 | +83 | +1 | 78 | +521 | 108 | 101 | 93 | 98 | 103 | 101 | 107 | 103 |
| CRV | Etazon Andrew | Ramos | O Man | GfW | 60 | +187 | n | 0 | 66 | -260 | +0.47 | +0.05 | +26 | +5 | +13 | n | 52 | +654 | 109 | 104 | 58 | 105 | 105 | 108 | 105 | 109 |
| CRV | De-Su Oman Goli-Et | O Man | Bw Marshall | Gnat | 83 | +186 | +20 | 116 | 93 | +829 | +0.08 | -0.02 | +43 | +27 | +94 | +1 | 64 | +358 | 108 | 100 | 89 | 105 | 106 | 108 | 104 | 109 |
| CRV | De-Su Oman Goli-Et | Paramount | Shuttle | GfW | 60 | +185 | n | 0 | 66 | +185 | +0.44 | +0.01 | +57 | +35 | +156 | n | 53 | +398 | 103 | 95 | 58 | 102 | 103 | 107 | 103 | 109 |

top 50 nvi bulls of CRV =
6 proven + 44 young

| | | reliability | nvi |
|------------|--------|-------------|-----|
| ■ Atlantic | young | 60% | 233 |
| ■ Impuls | proven | 80% | 233 |
| ■ Improver | proven | 81% | 176 |



Production traits

| % Rel | Dtrs | Herds | Base | Source |
|-------|------|-------|------|--------|
| 63 | 0 | 0 | Z | GFw |

| Kg milk | % fat | % protein | Kg fat | Kg protein | INET |
|---------|-------|-----------|--------|------------|------|
| 880 | -0.02 | 0.02 | 36 | 32 | 107 |

Functional traits

| Sire | | | | | % |
|--------------|----|----|----|-----|-------------|
| Calving ease | | | | | 108 82 |
| Gest. length | | | | | 101 92 |
| Birth weight | | | | | 93 83 |
| Vitality | | | | | 101 56 |
| Beef index | | | | | 98 VW |
| | 88 | 92 | 96 | 100 | 104 108 112 |

| Daughters | | | | | % |
|-------------------------|----|----|----|-----|-------------|
| Female fertility | | | | | 100 49 |
| NR | | | | | 98 45 |
| Calving interval | | | | | 102 52 |
| Intv. 1st-last insemin. | | | | | 100 42 |
| Mat. Calving process | | | | | 102 53 |
| Mat. Vitality | | | | | 98 46 |
| Udder health | | | | | 105 58 |
| Clinical mastitis | | | | | 103 52 |
| Subclin. mastitis | | | | | 106 45 |
| Hoof health | | | | | 105 37 |
| Milking speed | | | | | 102 63 |
| Temperament | | | | | 99 47 |
| Body weight | | | | | 103 VW |
| Persistence | | | | | 106 49 |
| Rate maturity | | | | | 105 41 |
| | 88 | 92 | 96 | 100 | 104 108 112 |

Conformation traits

| % Rel | Dtrs | Herds | Base | Source |
|-------|------|-------|------|--------|
| 58 | 0 | 0 | Z | GFw |

| Conformation traits | | | |
|-----------------------|----|----|--------------------|
| Frame | | | 109 |
| Dairy strength | | | 105 |
| Udder | | | 111 |
| Feet & Legs | | | 104 |
| Final score | | | 111 |
| Stature | | | 110 |
| Chest width | | | 102 |
| Body depth | | | 105 |
| Angularity | | | 105 |
| Condition score | | | 101 |
| Rump angle | | | 101 |
| Rump width | | | 103 |
| Rear legs, rear view | | | 99 |
| Rear leg set | | | 97 |
| Foot angle | | | 100 |
| Locomotion | | | 101 |
| Fore udder attachment | | | 110 |
| Front teat placement | | | 105 |
| Teat length | | | 98 |
| Udder depth | | | 110 |
| Rear udder height | | | 109 |
| Central ligament | | | 106 |
| Rear teat placement | | | 105 |
| | 88 | 92 | 96 100 104 108 112 |

Reference populations of cows

- Increase reliability for traditional traits
 - ▶ fertility, hoof health
- GEBVs for new traits
 - ▶ feed intake & feed efficiency
 - ▶ oestrus behaviour (pedometer)
 - ▶ subclinical ketosis (acetone, BHB)
 - ▶ milk fatty acid & protein composition
- Need 10,000s cows
- Increase benefit of genotyping for farmer



Multi-breed genomic selection

- Combine favourable traits
 - ▶ Holstein production x Jersey fertility (New Zealand)
- Crossbreds have lot of variation
 - ▶ detect best crossbred with genomics
- Across-breed genomic evaluation needs:
 - ▶ large multibreed reference population
 - ▶ very high marker density (777K)



Summary

- CRV is early adopter of genomic selection
- Full implementation in breeding program
- Official GEBVs since 2010
 - ▶ no biases due to bull dam info
 - ▶ results according to expectation
- EuroGenomics partner
 - ▶ large reference population, joint R&D
- Future reference population
 - ▶ cows, novel traits, multiple breeds

