Origin of Northern European cattle breeds

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November 30, 2018
Where are the data from?

<table>
<thead>
<tr>
<th>Traditional Danish Breeds</th>
<th>Nordic Reference Breeds</th>
<th>European Reference Breeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Danish Genome Management Project</td>
<td>• 1000 Bull Genomes Project</td>
<td>• 1000 Bull Genomes Project</td>
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<tr>
<td>• Nina Poulsen (Food Science, AU)</td>
<td>• Islandic Cattle Federation</td>
<td>• WIDDE (INRA, France)</td>
</tr>
</tbody>
</table>
Red Danish Dairy Cattle

- Traditional Danish
- Origin in 19th century
- Native Danish cattle crossed with Schleswig cattle
  - Angler
  - Ballum (extinct)
  - North Schleswig cattle (extinct)
- Traditionally dual-purpose
- 1950 ~1 million animals
Red Danish Conservation Breed

- Since 1970, increased focus on milk production
- Crossbreeding with Brown Swiss, Holstein, and recently Nordic Red led to modern Danish RDC (RDCDNK)
- Tiny remnant population of pure bred conservation breed (RDM 1970) ~200 animals
Genotype Data

Observe almost 800,000 positions in genome
Breed History with Molecular Data

- Genetic differentiation of Northern European cattle
  - Population structure
  - Relationships among breeds
- Breed origin
- Detection of admixture
- Genomic inbreeding
Old Danish Red very different from modern SWE, NOR, FIN Red
PCA

Modern Danish Red very diverse
Pre-crossbreeding (1970s)

Danish Red distinct cluster

![Graph showing genetic distances between different clusters and breeds. The graph illustrates the genetic relationships among clusters such as BSW, RDCNOR, HOLDNK, tRDM, Old Angler, New Angler, etc., with specific points highlighting the RDM70 cluster.]
Pre-crossbreeding (1970s)

Angler and old Danish Red similar

![Graph showing genetic distances between different breeds of Angler and old Danish Red.](image)
Crossbreeding in 1980s:

Extensive crossing with Brown Swiss
Crossbreeding in 1990s:

Extensive crossing with Holstein

Genetic distance PC1 (3.2 %)

Genetic distance PC2 (3.1 %)

BSW, RDCNOR, HOLDNK, tRDM, Old Angler, mRDCDNK 80ies, RDCSWE, RDCFIN, SDM-65, cRDM-70, New Angler, mRDCDNK 90ies
After 2000:

Crossing with Swedish and Finnish Red

[Graph showing genetic distance with labels for Nordic Red and RDCDNK 2000]
Admixture

- Detects distinct breed ancestries
- Ancestry proportions evaluated for each number of ancestries
- Ancestries can be breed specific or shared among breeds
- An individual's ancestry is proportionally attributed to the ancestry components
How to read admixture

Red Cattle Origin (3 ancestries)

- One breed
- Vertical bar: individual
- Color: ancestry
Admixture

* highly admixed  
→ mislabeled animals

Homogeneous breed
Heterogeneous breed
Admixture

- Geographic gradient
- Confirm DK distinct from other Scandinavian RDC
- Modern RDC DNK synthetic breed
TreeMix – Migrations

- Reconstructs relationships between populations
- Infers migration events between diverged populations
- Root: N´Dama (Afr. taurine)

N´Dama: West African taurine breed
TreeMix – Migrations

Complex migrations among Scandinavian breeds
Pedigree vs. Genomic Inbreeding

- Pedigree inbreeding
  - Traceable
  - Incomplete pedigrees
  - Incorrect pedigrees

- Genomic inbreeding
  - Reliable (insensitive to pedigree errors)
  - Independent of pedigree
  - Traces both old and recent events
Runs of Homozygosity

- Inbreeding detected through homozygous regions (ROH)
- Fraction of ROH in genome measures inbreeding ($F_{ROH}$)
- $F_{ROH} > F_{PED}$
- In time, ROH decay through recombination
- Short ROH reflect (potentially very) old events
- Long ROH reflect recent inbreeding
Genomic Inbreeding ($F_{ROH}$)

**Old RDM:**

- Oldest bull in genebank (18.80%)

**cRDM 1970:**

- Individual with the highest $F_{ROH}$ (53.51%)
Genomic Inbreeding ($F_{ROH}$)
Conclusions – Danish Red Breeds

- Genebank and living old Danish Red are close
- Old Danish Red related to Angler
- Old Danish Red very different from modern SWE, NOR, FIN Red cattle
- Modern Danish Red is a synthetic breed, admixed with Brown Swiss, Holstein, and Norther Red
Conclusions

- Northern and Central European cattle group into 5 clades plus island breeds
  - Alpine, Brown Swiss, Holstein, Nordic Red, and Danish Red

- Old Danish Red only pure bred representative of its clade

- Grouping of island breeds unclear
Management

- Admixture identifies disagreement between breed label and molecular data

- Would not be known without molecular information!

- Could lead to unwanted admixture