ReDiverse:
Biodiversity within and between European Red Dairy Breeds – Conservation through utilization

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IRDBF Conference 2019
26th March 2019

Outline

➢ Motivation

➢ Objectives of ReDiverse

➢ Involved partners

➢ Work packages

➢ Expected outcomes of ReDiverse

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Motivation

➢ European Red Dairy Breeds (ERDB) represent a unique source of genetic diversity

- complex histories of gene flow and connectedness
- local adaptation to various environments
- cultural heritage

➢ ERDB are well known for superior functional characteristics

- high fertility
- outstanding udder health
- low incidence of stillbirth
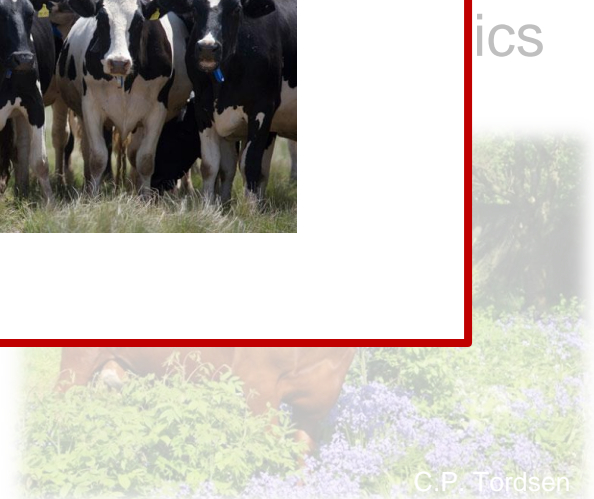- good conformation of legs and claws

C.P. Tordsen

➢ European Red Dairy Breeds (ERDB) represent a unique source of genetic diversity

Despite their qualities, ERDB are increasingly replaced by higher yielding breeds (e.g., Holstein Friesian)

➢ ics

• good conformation of legs and claws

C.P. Tordsen

Importance of genetic diversity

**Genetic diversity – a resource deserving protection**

➢ Animal genetic diversity is a unique and irreplaceable heritage

➢ Essential for maintaining the adaptability to changing environments

➢ Insurance future breeding options

➢ Genetic diversity in livestock declines significantly

➢ Globally, 16% of all livestock breeds have been lost during the last 100 years (Scherf, 2000)

Utilization will ensure conservation!

Dairy breeds in Northern Germany

Development of dairy cows under milk recording in Schleswig Holstein
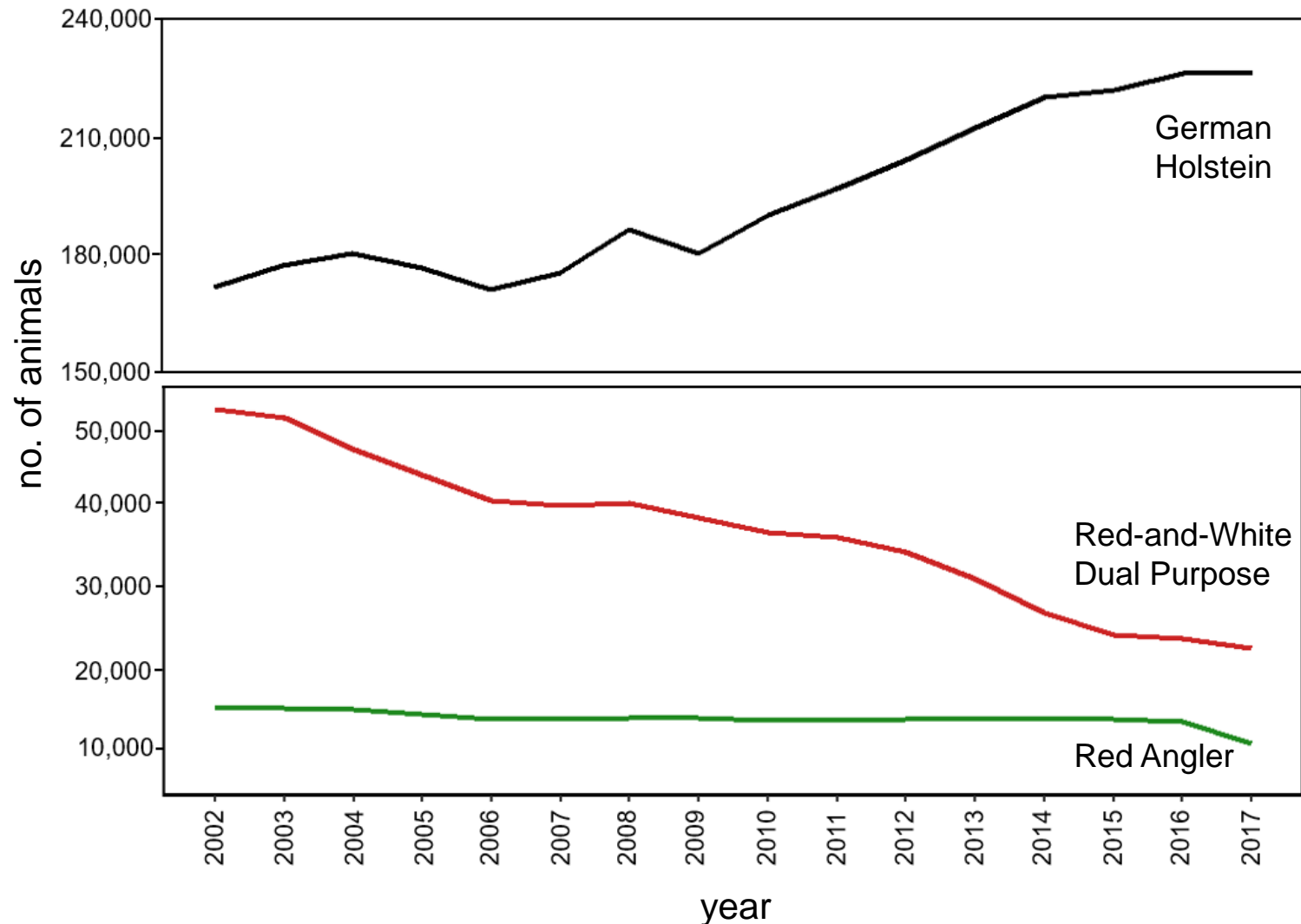
(LKV, 2017)

Dairy breeds in Northern Germany

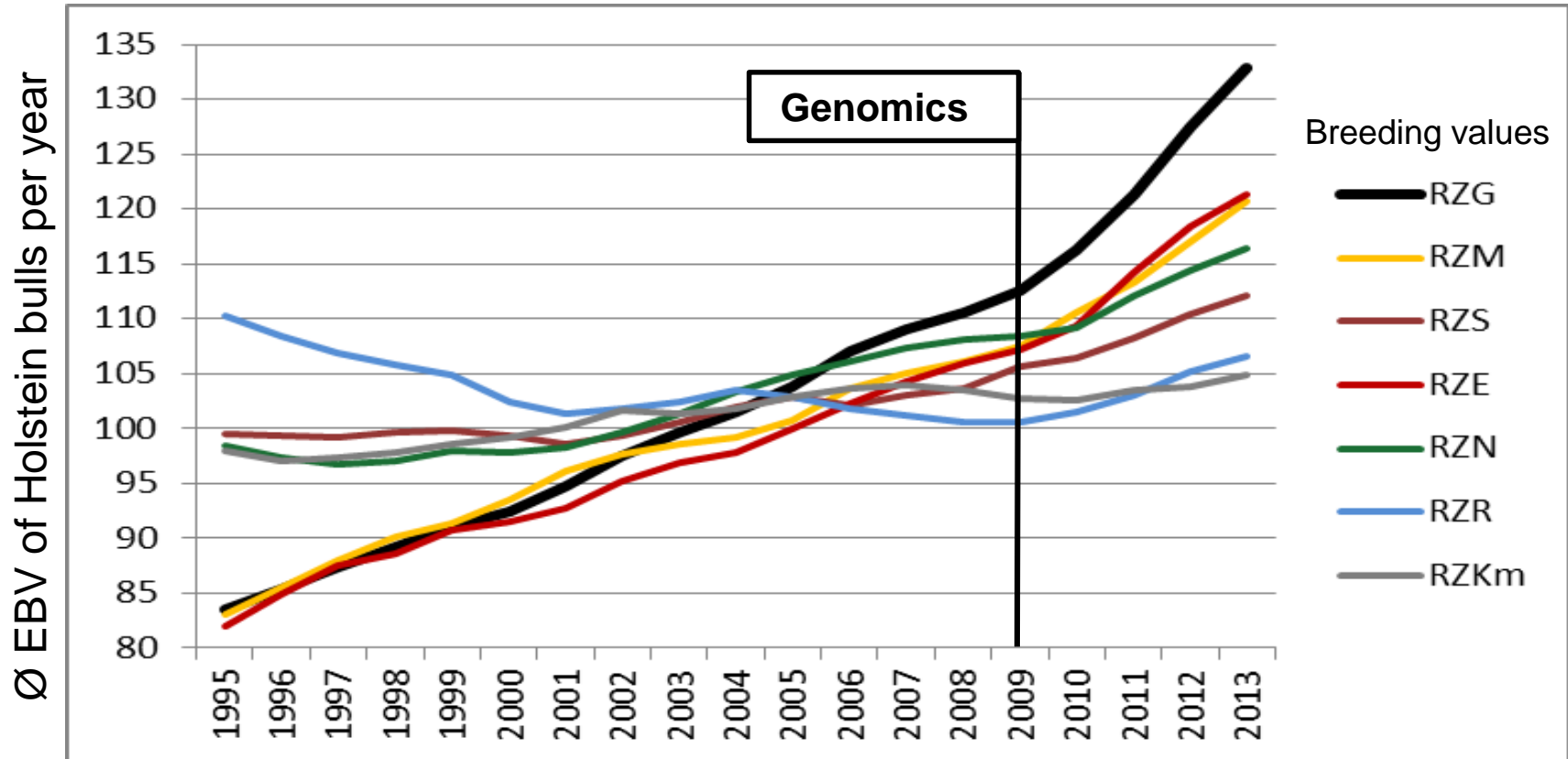**Table:** Average performances of breeds (LKV SH, 2017)

	Red Angler	Red-and-White Dual Purpose	German Holstein
Number of animals in milk recording (2017, SH)	10,257	20,730	233,003
Milk yield (kg)	7,766	6,771	8,804
Fat %	4.60	4.34	4.09
Protein %	3.61	3.50	3.41

Impact of genomic breeding

Genetic gain in German Holstein

(Reinhardt, 2014)

RZG 1995-2008 = Ø +2.1 per year
RZG 2010-2013 = Ø +5.1 per year

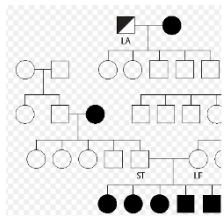Genomic selection has doubled genetic progress

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ReDiverse – Main objectives

Development and implementation of methods and strategies for sustainable use of genetic diversity provided by European Red Dairy Breeds


➢ Investigation of population structure and genetic composition of Red dairy breeds

➢ Genetic analyses → Cooperative reference population
→ Breed-specific SNP-Chip

➢ Proteomic analyses → Identification and characterization

➢ Design and evaluation of breeding programs to ensure genetic gain and genetic diversity

➢ Exploration of farmers' preferences keeping Red Dairy breeds
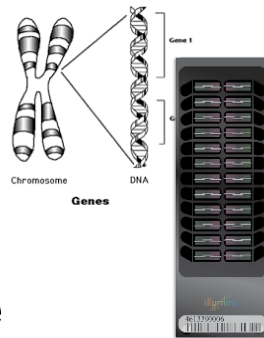
ReDiverse – Structure of project
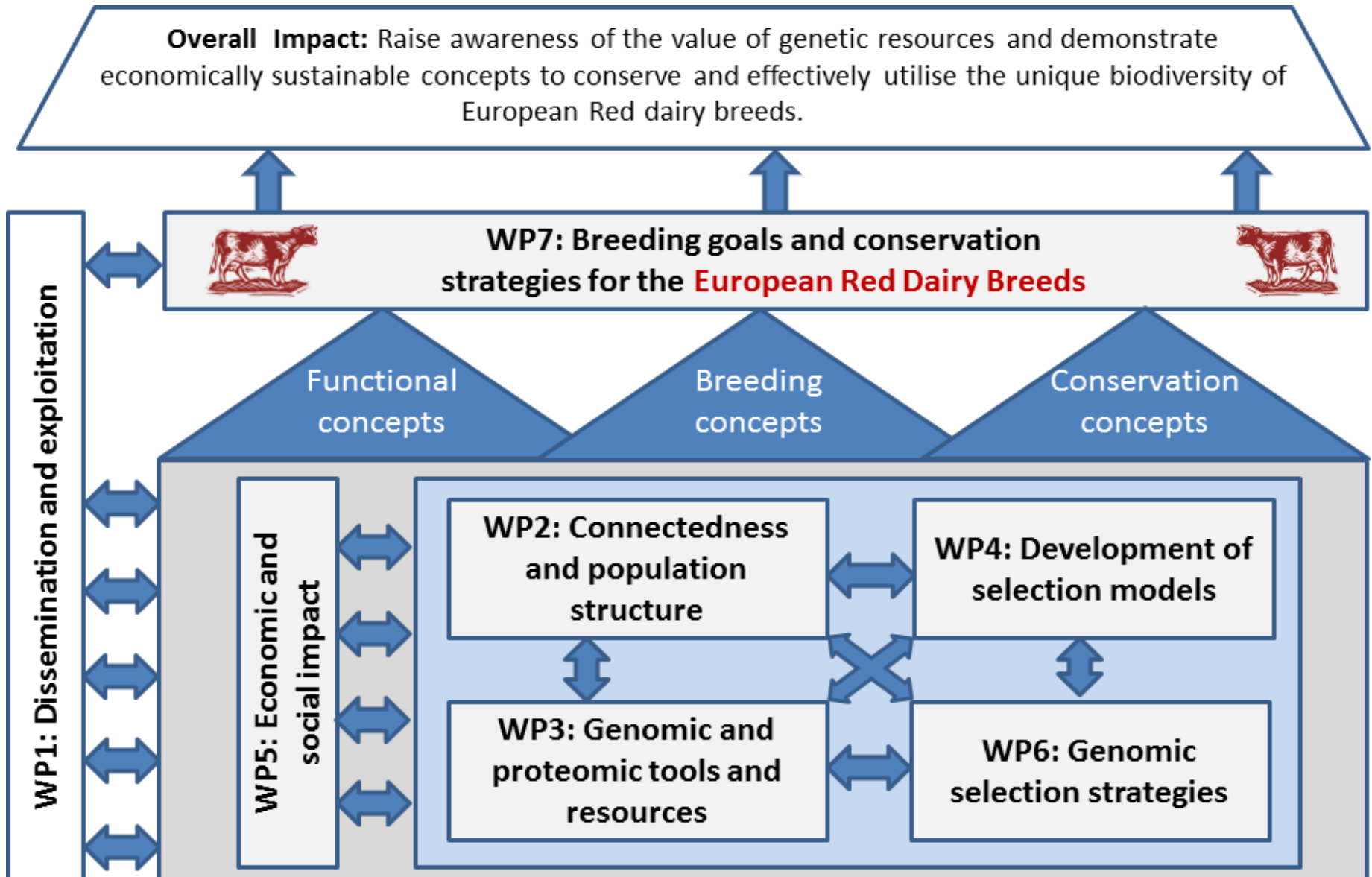
European Red Dairy Breeds

Breed	Herdbook animals
Meuse–Rhine-Yssel	17,771
Groningen White Headed	2,488
Deep Red	1,563
Dutch Red Friesian	700

Breed	Herdbook animals
Finnish Ayrshire	190,000
Swedish Red and White Cattle	130,000
Modern Red Danish Cattle	40,000

Breed	Herdbook animals
Latvian Brown	44,280
Lithuanian Red	30,295
Estonian Red	18,000

| Breed	Herdbook animals
Modern Angeln Cattle	10,257
Red and White Dual Purpose	2,846
Vorderwald Cattle	6,050
Hinterwald Cattle	600

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Scientific partners

➢ Germany (Universities of Kiel, Kassel & Hohenheim)

➢ The Netherlands (WUR)

➢ Denmark (Aarhus University)

➢ Sweden (SLU, Interbull)

➢ Norway (NMBU)

➢ Lithuania (LUHS)

➢ Poland (Wroclaw University)
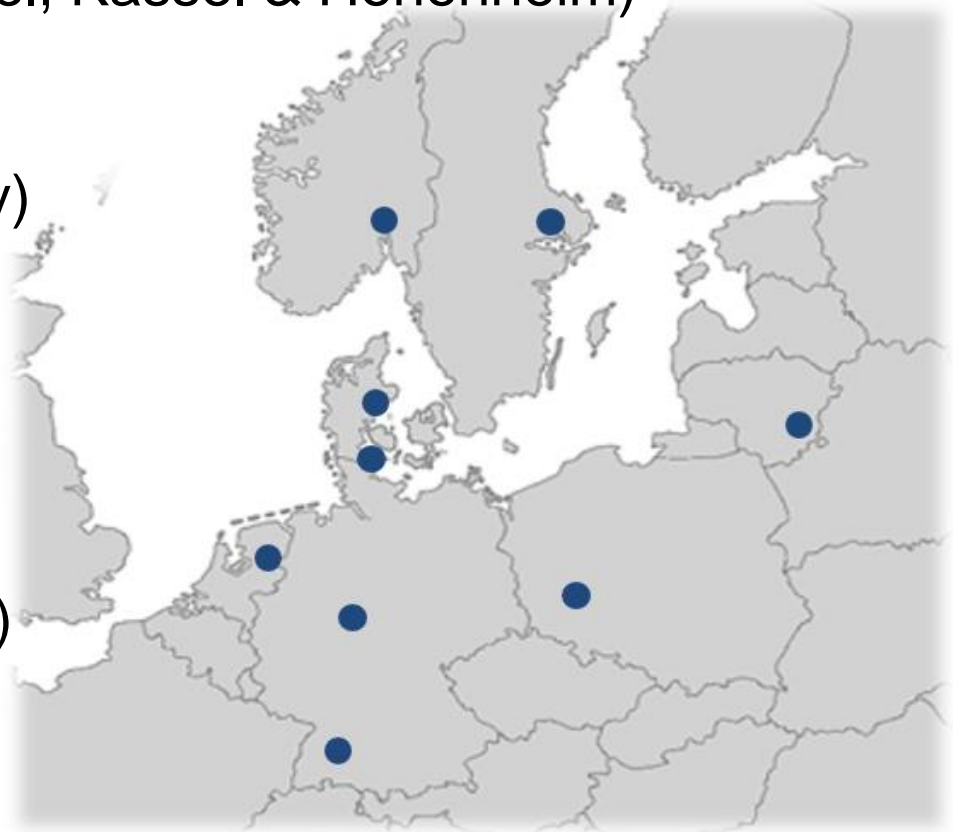
Industrial partners

➢ CRV

➢ Geno

➢ Rinderzucht Schleswig Holstein eG

➢ Viking Genetics

➢ Lithuanian Red Cattle Improvement Association

➢ Animal Breeders Association of Latvia

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Leader WP2: Dirk-Jan De Koning, SLU Sweden

- Investigation of population structure and genetic connectedness

  → Determination of genomic relationships and distances between breeds

- Investigation of phenotype recording schemes between ERDB

  → Defining clear phenotypes which will be recorded across countries within a reasonable time
  → Harmonization of recording schemes

- Determination of recent migration from other breeds

- Identification of key animals for further genotyping and sequencing

WP 2 – Genetic connectedness + population structure

Numbers of pedigree information per sex and reporting country

	FEMALE	MALES	TOTAL
Lithuania	9 789	9 211	**19 000**
Denmark, Sweden, Finland	4 855 904	1 490 092	**6 345 996**
Netherlands	2 217 343	256 627	**2 473 970**
Germany	4 089	815	**4 904**
Latvia	58 025	4 517	**62 542**
Poland	6 893	713	**7 606**
Norway	1 648 872	445 426	**2 094 298**
TOTAL	**8 800 915**	**2 207 401**	**11 008 316**

(S.Nyman & A.M.Johansson, 2018)

Verification of pedigree information ➡ 3 009 686 duplicates

Existing evaluation schemes for Red dairy breeds per trait/country

Trait/Country	Production	Udder health	Conformation	Longevity	Calving ease	Female fertility	Workability
Lithuania	X	X					
Denmark, Sweden, Finland	X	X	X	X	X	X	X
Netherlands	X	X	X	X	X	X	X
Germany	X	X	X	X	X	X	X
Latvia	X	X					
Poland							
Norway	X	X	X	X	X	X	X

(S.Nyman & A.M.Johansson, 2018)

WP 3 – Development of genomic and proteomic tools

Leader WP3: Bernt Guldbrandtsen, Aarhus University

AARHUS
UNIVERSITY

- ➢ Analysis of genomic data with respect to patterns of milk protein variants
    - → Investigation of implications for human health

- ➢ Design of a SNP chip customized for ERDB
    - → Improved QTL results
    - → Promotion of milk protein variants
    - → Support of genomic prediction

- ➢ Identification of breed differences at sequence level

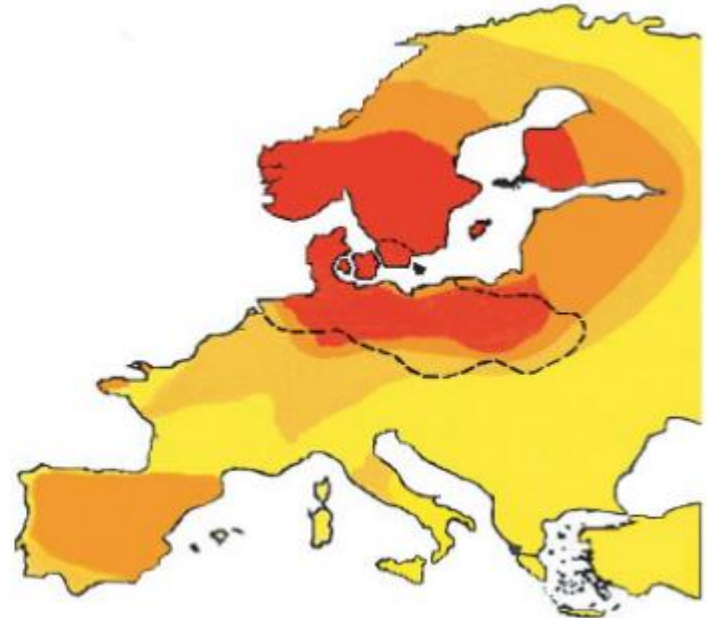- ➢ Improve the understanding how admixture is detectable in genomic data

Milk protein variants
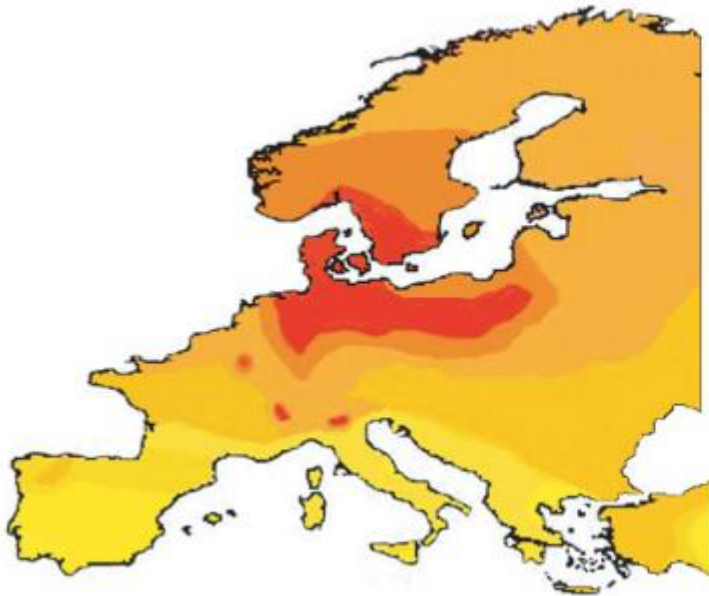
Milk protein diversity　　　　**Incidence of lactose tolerance**
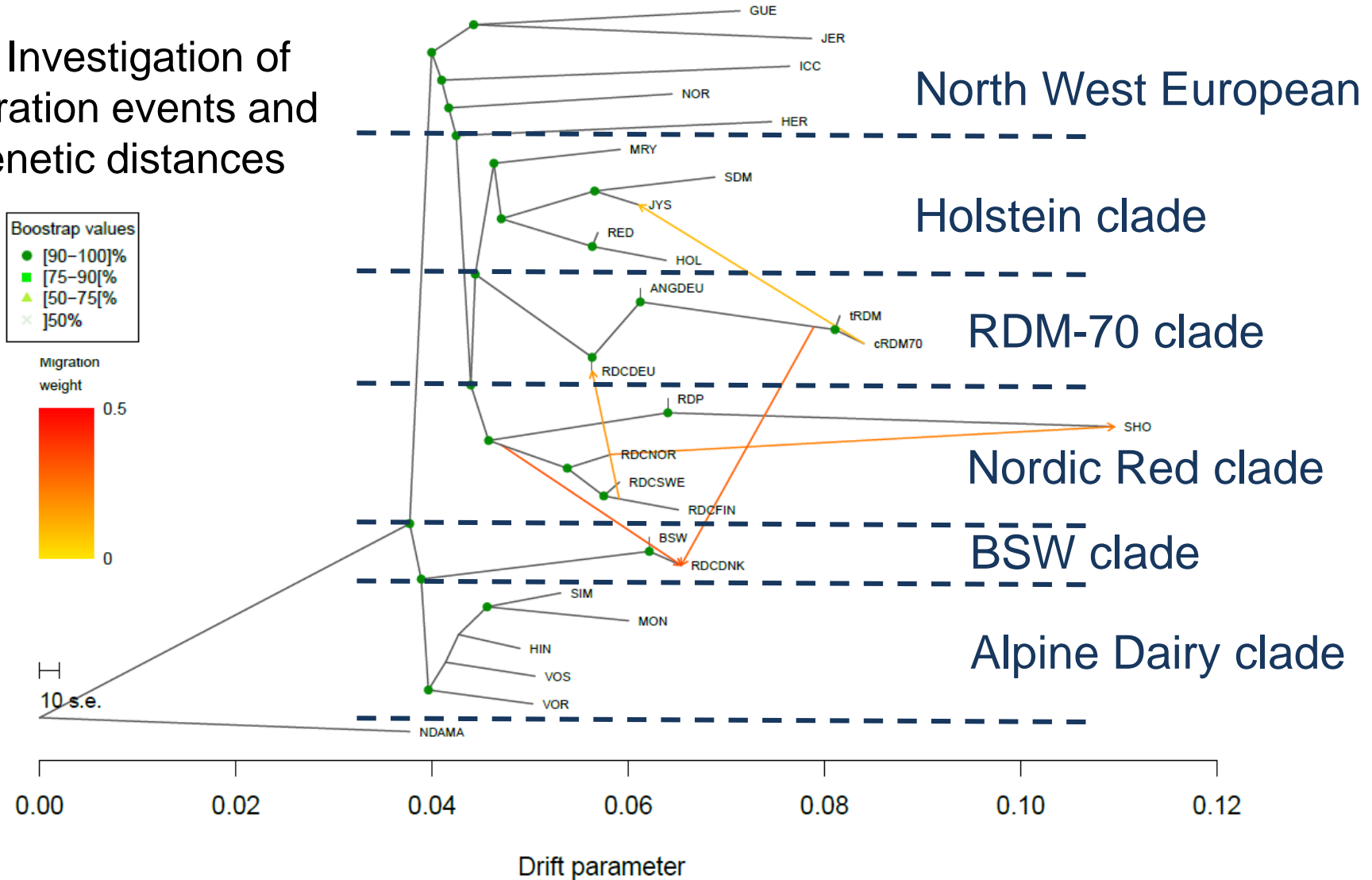

Adapted from Beja-Pereira et al. (2003)

➡ Beja-Pereira et al. (2003) have found coincidence between the milk protein diversity in cattle breeds and the geographic distribution of the lactase persistence allele in humans

TreeMix analysis

→ Investigation of migration events and genetic distances

North West European

Holstein clade

RDM-70 clade

Nordic Red clade

BSW clade

Alpine Dairy clade

(Anna Schönherz, 2018)

**Leader WP4: Jörn Bennewitz, University of Hohenheim**

UNIVERSITY OF
HOHENHEIM

➢ Development and evaluation of selection methods

→ Maximization of purebred and crossbred performance while preserving genetic uniqueness of ERDB

➢ Development of breeding programs for the genomic prediction of crossbred performance

➢ Comparison of simulated breeding programs

→ Focussing on genetic gain and genetic uniqueness

Conflicting objectives in animal breeding programs

R-package **optiSel**
(Wellmann, 2019)
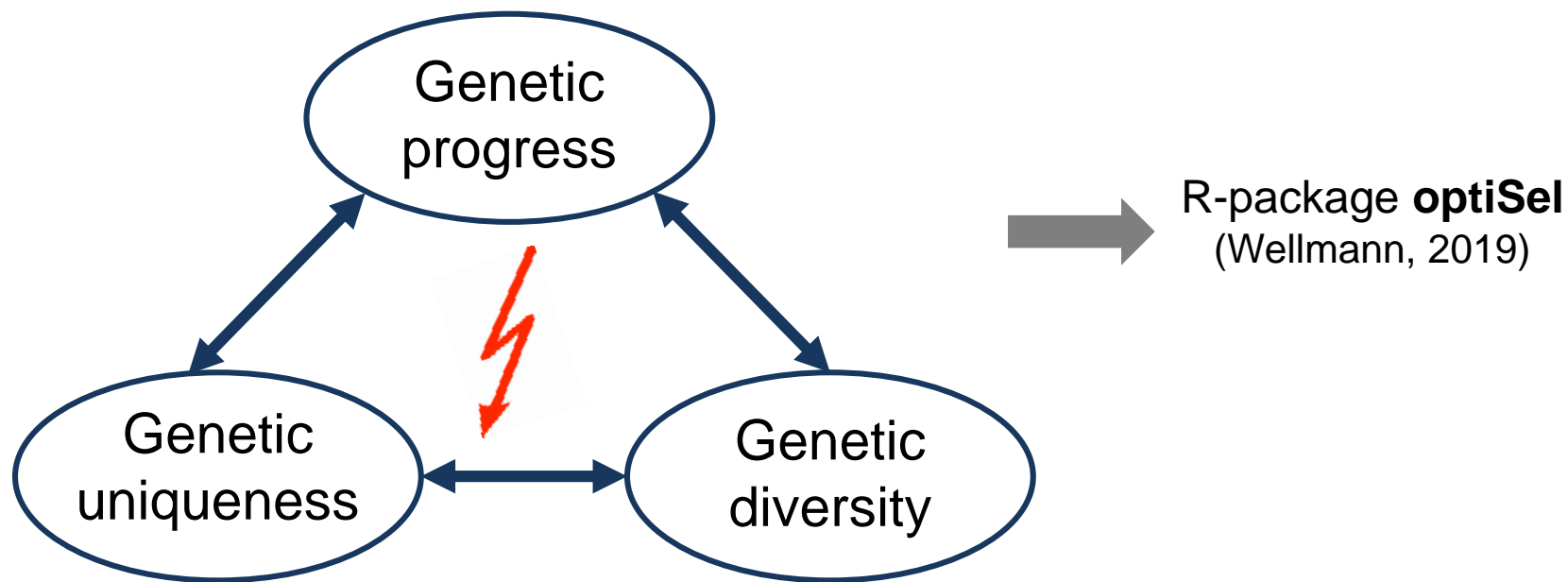
Development and evaluation of selection methods to maximise performance while preserving the genetic diversity and genetic uniqueness provided by ERDB

WP 5 – Economic and social impact

Leader WP5: Uwe Latacz-Lohmann, Kiel University

➤ Assessment of benefits and costs of conserving genetic diversity at the farm level

➤ Evaluation of farmers' preferences keeping and breeding Red dairy cattles

➤ Determination of farmers' preferences for the introduction of Red dairy cattles genes in high yielding breeds (e.g. HF)

Applied methods: Quantitative approaches from social sciences, e.g. Discrete Choice Experiments, interviews

Which determinants influence farmers' participation in conservation programs for dairy cattle breeds?

➡ Discrete Choice Experiments, 159 German cattle breeders

	Contract 1	Contract 2	Opt-out
Compensation payment	250€/LU/year	250€/LU/year	No contract
Collective Bonus (population increase > 5%)	40€/LU/year	0€/LU/year	
Conservation breeding program (pairing)	No	Yes	
Keeping conditions	No requirements	Access to free-range area or pasture	
Contract duration	5 yrs	1 yrs	
I choose	☐	☐	☐

(Julia Schreiner, 2018)

WP 5 – Economic and social impact

	Coefficient	WTA [€/LU/year]
Compensation payment	0.015***	-
Bonus = 40€/LU/year	-0.0689	5
Bonus = 80€/LU/year	0.453***	-30
Conservation breeding program	-0.159	11
Access to free-range area or pasture	0.230	-15
Access to free-range area or pasture+ prohibition of slatted floors	-2.475***	165
Contract duration = 1 year	0.2706	-18
Contract duration = 5 years	0.4674	-31
Contract duration = 10 years	-1.627***	108

(Julia Schreiner, 2018)

➤ Monetary incentives contribute to farmers' willingness to participate in conservation programs

➤ Conract duration → short term contracts were more attractive for farmers → flexibility, independence

WP 5 – Economic and social impact

What are motivations for farmers keeping and breeding Red Dairy cattles?

➡ Q-methodology (systematic analysis of subjective attitudes), carried out with 66 cattle breeders

Some results:

✚ ‚ERDB are characterized by good health, claws and conformation → lower veterinary costs'

✚ ‚ERDB show higher values for milk ingredients (fat + protein) → guarantee for income even milk price is low '

✚ ‚we are keeping ERDB due to traditional reasons, we are emotionally attached'

✚ ‚we are keeping ERDB becauce we are concerned about the cultural value of our region '
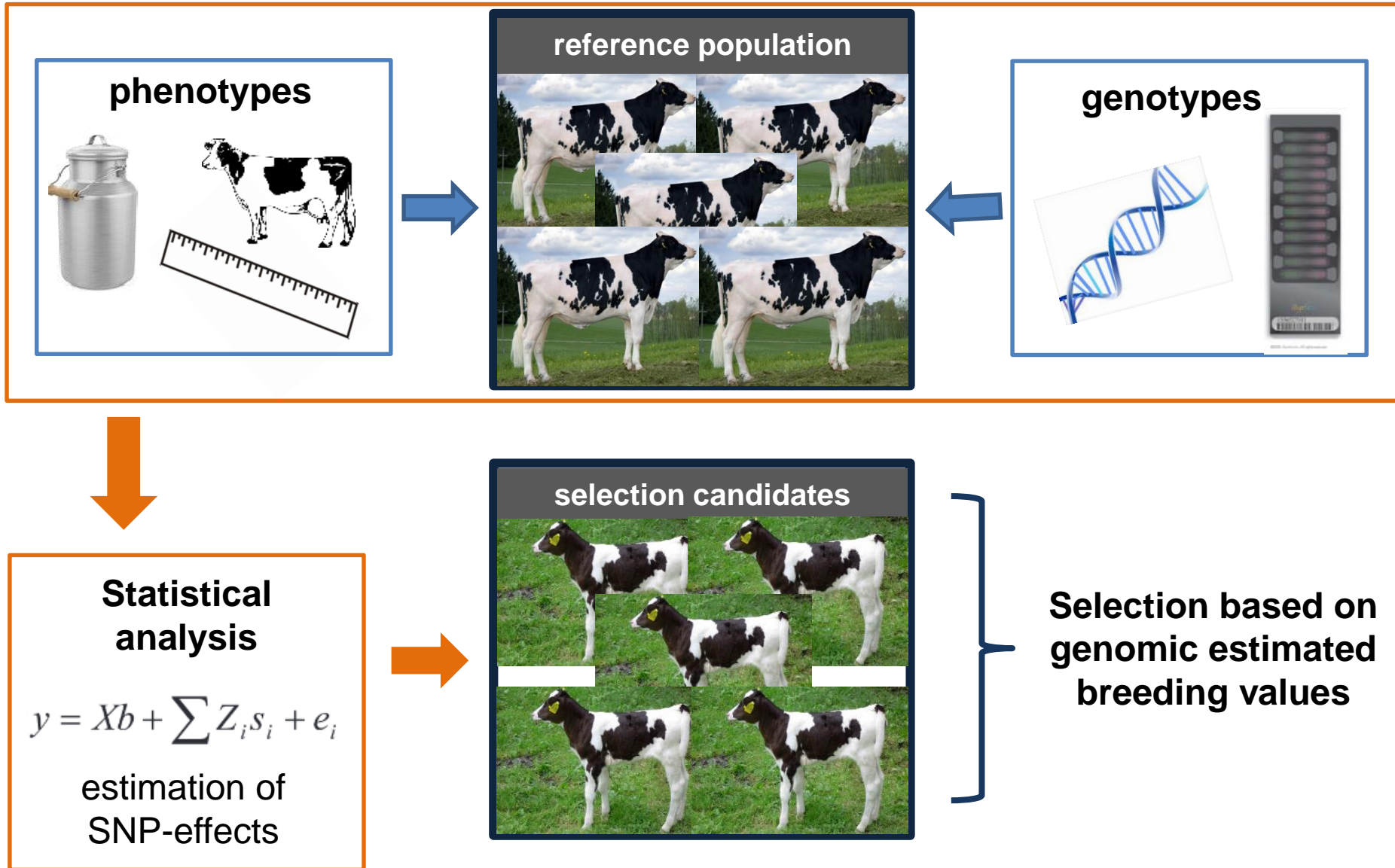
(Julia Schreiner, 2018)

Leader WP6: Mario Calus, Wageningen University

➢ Improvement of genomic prediction methods for across-breed evaluations and for heterogeneous populations

→ Focussing on maintaining genetic diversity

➢ Investigation of the potential for implementation of genomic selection in ERDB

Increase competitiveness and create a long-term perspective for European Red Dairy Breeds

Genomic selection

phenotypes

reference population

genotypes

Statistical analysis

$$y = Xb + \sum Z_i s_i + e_i$$

estimation of SNP-effects

selection candidates

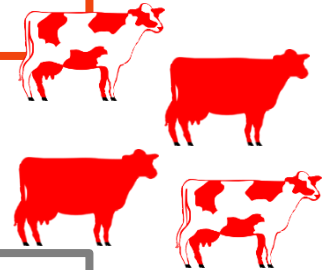**Selection based on genomic estimated breeding values**

Challenges: European Red Dairy breeds

- are characterized by small population sizes → few progeny tested bulls
- are heterogeneous populations

Possible solution: Multi-breed reference population

- composition of reference population ?
- which breeds are useful to include ?

Estimation of M_e (effective number of chromosome segments)

- Indicator for relatedness
- Directly predict expected accuracy

Data

- BovineSNP50 data of 5 Dutch Red dairy breeds

Breed	N
MRY	423
Groningen White Headed (GWH)	129
Dutch Belted (DB)	41
Dutch Friesian (DF)	352
Deep Red (DR)	44

(Jovana Marjanovic, 2018)

Results

	MRY	GWH	DB	DF	DR
MRY	293				
GWH	17906	151			
DB	14883	16315	104		
DF	16452	10890	7625	212	
DR	3662	17516	17047	14560	149

(Jovana Marjanovic, 2018)

Within M_e

Between M_e

- MRY and DR are most closely related

- DF was most closely related to DB

- For GWH, DF was the closest breed

- The most distant relationships DR and DB, DR and GWH, and GWH and MRY

Results

	MRY	GWH	DB	DF	DR
MRY	293				
GWH	17906	151			
DB	14883	16315	104		
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Within M_e

Between M_e

(Jovana Marjanovic, 2018)

- MRY and DR are most closely related

- DF was most closely related to DB

- For GWH, DF was the closest breed

- The most distant relationships DR and DB, DR and GWH, and GWH and MRY

- M_e shows high variability in relatedness
- Multi-breed RP should be much larger than single-breed RP

WP 7 – Development of breeding goals + conservation strategies

Leader WP7: Morten Kargo, Aarhus University

➢ Breeding goal setting for European Red Dairy Breeds

→ Development of national + transnational breeding objectives

➢ Breeding scheme simulations

➢ Evaluation of breeding schemes with respect to genetic gain, genetic diversity and promotion of breed-specific characteristics

→ With respect to genetic gain, genetic diversity and promotion of breed-specific characteristics

Calculation of economic values for Red Dairy breeds

➢ Determination of optimal economic selection indices for regional production conditions

➢ Economic values were already calculated for 3 German dairy breeds (Holstein Friesian (HOL), Angler (ANG), Red-and-White Dual Purpose (RDN))
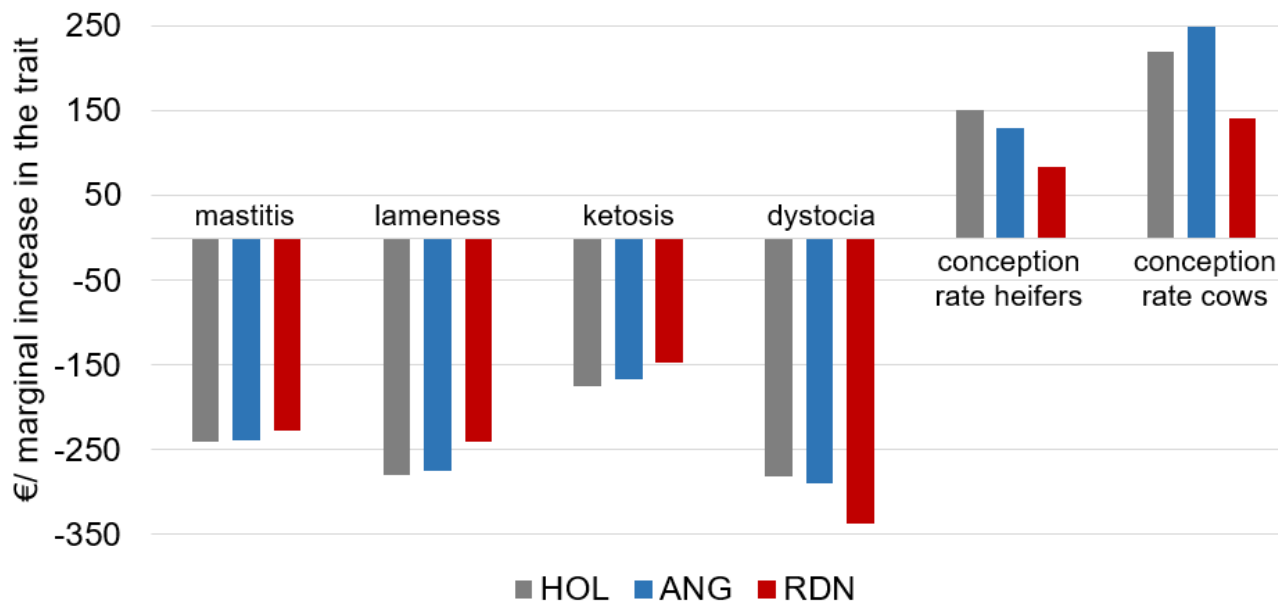
Applied methods:

➢ Bio-economic model SimHerd (Østergaard et al., 2005)

→ Simulation of typical structures in dairy herds
→ Input: phenotypic records (performance, health, reproduction)

➢ Multiple regression with mediator variables (Østergaard et al., 2016)

→ Prevention of ‚double counting' of effects

Calculated EVs for selected breeding traits

Differences in EV's are due to different assumptions for:

- Performance levels
- Incidence rates
- Reproduction levels
- Market prices

➢ Calculation of economic values for other European Red Dairy Breeds should follow

Breeding scheme simulations

➢ Heterogeneous conditions regarding Red breeds in Europe

- Environmental and production conditions
- Market circumstances (prices, costs, political regulations)
- Different priorities of farmers (production, health, robustness)

➢ Enhancing coorporation between breeding organizations

- Planned workshop → to identify the needs and perceptions of industrial partners regarding the future of Red dairy cattle

➢ Simulation of breeding scheme scenarios with software ADAM

- To show the genetic and economic effects of different breeding scheme scenarios
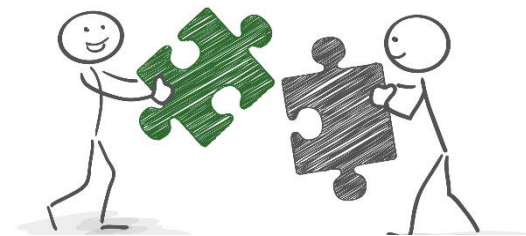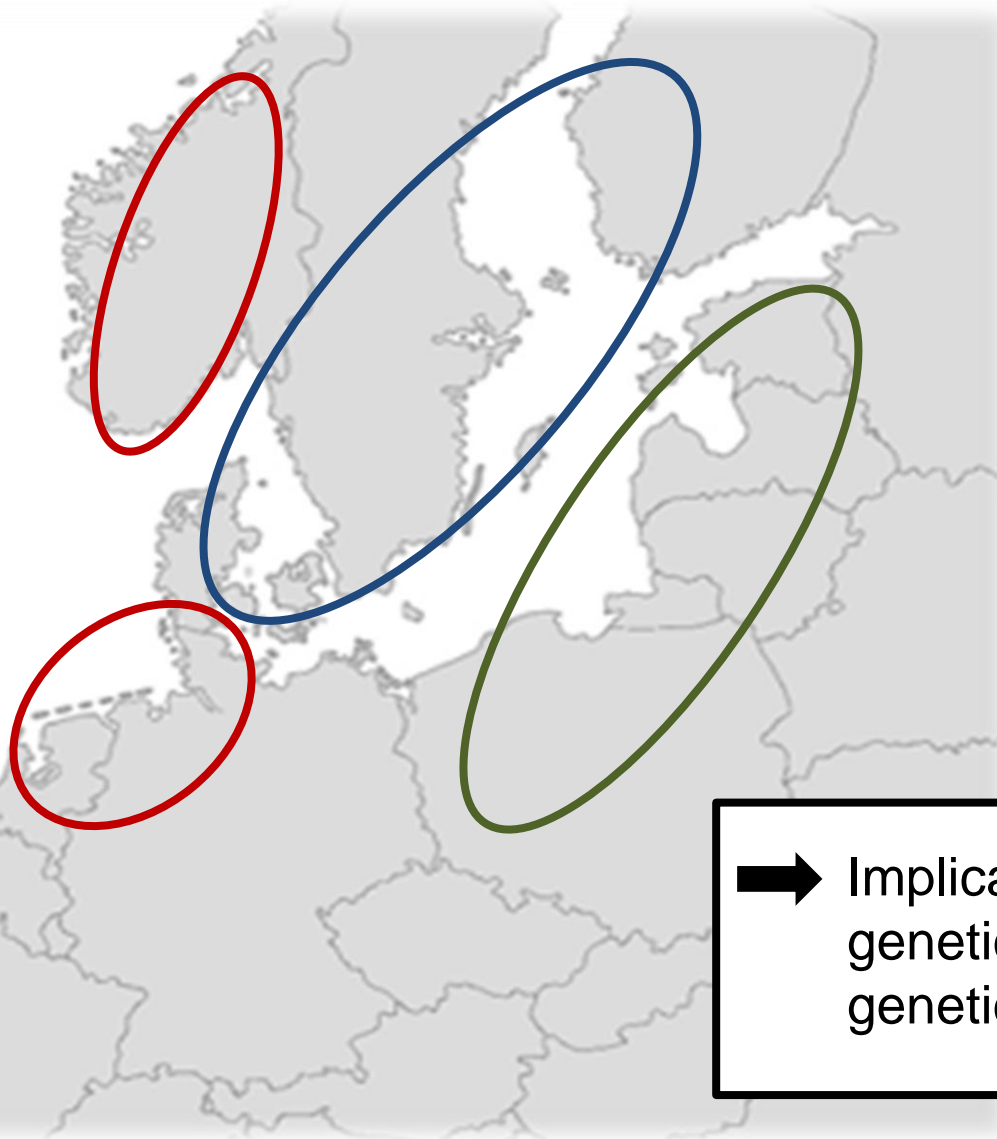
Dual purpose
Norwegian Red
MRY
RDN

Dairy type
Finnish Ayrshire
Swedish Red
Danish Red
Angler

Eastern Europe
Lithuanian Red
Latvian Brown
Polish Red

➡ Implications on genetic gain and genetic diversity

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➢ Tasks of the work packages

➢ Expected outcomes of ReDiverse

Expected outcomes

➢ Sustainable management of genetic diversity provided by European Red Dairy Breeds

➢ Formation of joint breeding programs

➢ Shared genomic resources

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Ultimately: preservation of European Red Dairy Breeds by improved breeding utilizing their unique characteristics

Thank you for your attention!

C.P. Tordsen

ERA-NET**SUSAN**