





# Synbreed –

# **Synergistic Plant and Animal Breeding**

# Network of excellence for interdisciplinary,

genome based research

GenSAP 11 November 2014







Accelerate progress in crop and livestock breeding

Increase the number of highly qualified young breeders

Strengthen German agricultural research

- visibility
- competitiveness
- cross linking





SequencingQuantitative GeneticsGenotypingPopulation GeneticsMetabolomicsStatistical GeneticsBioinformaticsBreeding Methods







# Synbreed partners



#### Technische Universität München

Plant Breeding (C.-C. Schön, Speaker) Animal Breeding (H.-R. Fries) Genome Oriented Bioinformatics (H.-W. Mewes) Genetics (A. Gierl) Human Genetics (T. Meitinger) Population Genetics (A. Tellier)

#### Helmholtz Zentrum München

Bioinformatics and Systems Biology/MIPS (K.F.X. Mayer) Human Genetics (T. Strom)

#### Bayerische Landesanstalt für Landwirtschaft

Animal Breeding (K.-U. Götz)

#### Georg-August-Universität Göttingen

Animal Breeding and Genetics (H. Simianer)

#### Universität Hohenheim

Bioinformatics (H.-P. Piepho) Plant Breeding (A. E. Melchinger) Crop Biodiversity and Breeding Informatics (K. Schmid)

#### Christian-Albrechts-Universität zu Kiel

Animal Breeding and Husbandry (G. Thaller)

#### Friedrich-Loeffler-Institute

Farm Animal Genetics (S. Weigend)

KWS SAAT AG (M. Ouzunova)

Lohmann Tierzucht GmbH (R. Preisinger)



Synbreed



# Synbreed data flow

G



rs

### **T1**



- joint development of statistical methods and software in application projects
- shared use of data generated in technology platforms
- development of generic bioinformatic concepts for data analysis
- generation of shared biological resources in resource projects
- · intensive material and data flow between partners
- integrative consolidation of results from the different projects

Population Genomics



#### T1 – Sequencing (HMGU-HG)

#### Maize

4 lines, 90x coverage 26 lines + 1 teosinte, 10x 9 landraces (24 S<sub>0</sub>/pop) 2x 6 landraces (2 DH/pop) 5x

### Cattle

140 animals, 10x

#### Chicken

3 Pools 20x
5 Individuals 25x
25 white layers 8x
25 brown layers 8x
40 Pools 15x



#### Maize

Illumina 50k SNP-Chip 5305 genotypes Affymetrix 600k SNP-Chip 960 genotypes

**Cattle** Illumina 777k SNP-Chip 3072 genotypes

**Chicken** Affymetrix 600k SNP-Chip 5376 genotypes



**T4 – Biomarkers** (TUM-GE)

-	TCOM TCNM						
and indus							
e.							
4							
201 2.5 20 27 301 2.5 20 375 Relation time to							

Calibration for maize, milk and egg yolk completed

Maize 90 ILs 460 DH lines (5x)

**Cattle** 391 milk samples (3x) plus 66 checks

**Chicken** 1649 egg samples (3x)



### **Statistical methods**

- ✓ Parametric/semi-/non-parametric and machine learning methods
- ✓ Procedures for cross-validation
- Methods accounting for genetically heterogeneous calibration samples
- Modeling approaches for G x E interactions
- Development of prediction models accounting for additive effects, dominance, epistasis, imprinting and non-genetic effects

### Implementation

- Development of genomic selection for maize and chicken breeding programs
- ✓ Implementation of genomic selection in existing breeding programs
- Optimization of breeding programs integrating genomic selection



### **Population genomics**

- High-throughput analysis pipeline for frequency and haplotype based tests for selection
- Development of tools for the comparison of expected and observed distributions of statistics for selective sweeps by means of forward simulations
- Analysis of LD and haplotype structure in experimental data
- Genome-wide scans for association and selection signatures
- Zoom into specific trait associated regions of the genome



- Graduate School 'Next Generation Breeding'
  - 14 courses on statistical inference, bioinformatics, selection theory, genome-enabled prediction
- Summer / Winter Schools
  - joint organization by several Synbreed partners
  - lecturers established scientists and students
  - high demand nationally and internationally (participants from > 20 countries)
- Foreign scholarships
  - 7 scientists to USA, Australia and France in high impact research groups

# Synbreed summer / winter schools





### 2010

Linear models and estimation of genetic parameters with Larry Schaeffer

### **2011**

Next generation sequence analysis: practice and departure to new frontiers with Mario Caccamo, Ben Hayes, Paul Kersey, Jared Simpson

### 2012

# Population genomics of crop and livestock populations

with Michael Blum, Joachim Hermisson, Joseph Pickrell, Bertrand Servin

→ German-French cooperation: Alain Charcosset

### 2013

Advanced topics in plant and animal breeding with Bruce Walsh

### 2014

### From SNPs to gene networks

with Guilherme Rosa, Fabian Theis, Pascal Braun, Helge Stark, Ngoc-Thuy Ha

### 2015

#### **Selection theory**

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### **Contribution to consortia**

600k Chicken SNP Chip (with Roslin Institute, Affymetrix and others)

777k Cattle SNP Chip (with USDA, DPI and others)

**50k and 600k Maize SNP Chip** (with Illumina, Affymetrix, Trait Genetics, INRA, and others)

1.000 bull genomes project (initiated by Ben Hayes and Mike Goddard)

## Synbreed publications (2009 – 2014)

55 papers published in peer-reviewed journals
19 joint publications of Synbreed partners

7 across species



- Exchange of know-how
- Joint training for young academics
- Exchange between breeding companies (KWS/Lohmann)
- Joint technology development
  - Sequencing
  - Availability of technology platforms for animals and plants
  - Chip construction
- Joint new project proposals
- Joint publications
- Mutual invitations to meetings and conferences



### Synbreed – why we like it...

#### **Funding volume**

- strengthens position of plant and animal breeding
- reliable results due to large scale experiments

#### Funding period 5 years

• highly connected projects with mutual dependencies

### Flexibility of resource allocation

technological developments

#### **Public Private Partnership**

• immediate transfer of results into breeding

#### National and international visibility

 scientific advisory board, collaboration in chip consortia for maize/ chicken/cattle, TUM-IAS, invited talks, research stays, cooperations











#### New projects

- "Selection at work" DFG initiative
- Big Data MDSC Munich Data Science Center

#### **New centers**

 "Centre for integrated plant and animal breeding" at the University of Göttingen

### **Education and training**

- Continuation of summer schools and graduate education
- Development of an international graduate school

### International collaboration









# What's next?





Agricultural research is vital for addressing global challenges. Genome discovery enables us to study the genetic underpinnings of complex traits and has become a key component of many plant and animal improvement programs.

Bringing together experts in plant and animal genetics from public institutions and private industry we aim at creating a platform for fruitful discussions on current achievements, future challenges and on how to translate results from genome discovery into selection gain and breeding success.

#### Organisation and Contact:

Synbreed /Hans Eisenmann-Zentrum Dr. Ulrike Utans-Schneitz Dr. Ute Wiegand Ph.: +49 (0)8161/71-5226 Email: synbreed@tum.de Synbreed – Synergistic Plant and Animal Breeding

Understanding and

predicting complex

traits through genome

discovery



#### Keynote Speakers:

Mark Cooper, DuPont Pioneer, USA Natalia de Leon, University of Wisconsin, USA Mike Goddard, DPI Melbourne, Australia Pieter Knap, PIC International, Germany Klaus Mayer, Helmholtz Zentrum, Germany Guilherme Rosa, University of Wisconsin, USA Carl-Johan Rubin, Uppsala University, Sweden Maud Tenaillon, INRA, France

In addition to keynote lectures scientific findings from the Synbreed project will be presented.

04. - 06.03.2015

Technische Universität München Campus Weihenstephan, Freising, Germany Application Registration fee: 150,- Euro Registration: <u>www.synbreed.tum.de</u> Registration deadline: 15.12.2014

# Hybrid Breeding





# **Optimize Breeding Cycles**



Performance

Interconnected cycles

Genetic subgroups

Highly unbalanced data

Modified after Gordillo and Geiger 2008

				Median, [min ; max]	
Set	N	parents	crosses	lines per parent	lines per cross
S1	928	52	173	21 [1; 203]	3 [1; 63]
S2	842	73	287	12 [1; 129]	2 [1; 26]
S3	1085	148	246	6 [1; 115]	1 [1; 28]
S4	1017	58	130	13 [1; 455]	4 [1; 47]



### S1 grain yield

CV: random sampling within complete data set and tester subsets



Albrecht et al. 2014, TAG



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CV: random sampling within complete data set and tester subsets





# **Prediction across Breeding Cycles**



Albrecht et al. 2014, TAG

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Albrecht et al. 2014, TAG



# **Prediction across Breeding Cycles**





- GBLUP outperforms PBLUP for all traits and all genetic groups
- Introgression of unrelated material requires specific experimental designs
- Predictive abilities encouraging across cycles
- Merging data from several cycles seems favorable



GEFÖRDERT VOM







- The Roslin Institute, Edinburgh University (D. Burt) Research stay of S. Qanbari (UGÖ-TZ), 02/2011-04/2011, co-funded by ERF-grant
- University of California Berkeley (R. Nielsen)
   Research stay of S. Qanbari (UGÖ-TZ), 05/2012-11/2012
- Cornell University (J.-L. Jannink)
   Research stay of C. Riedelsheimer (UHO-PZ), 08/2012-12/2012, co-funded by Synbreed
- Department of Primary Industries, Melbourne (B. Hayes) Research stay of M. Erbe (UGÖ-TZ), 03/2011-08/2011, co-funded by Synbreed
- North Carolina State University, Raleigh (T. Mackay)
   Research stay of U. Ober (UGÖ-TZ), 10/2011-11/2011, co-funded by the DFG GRK 1644
- University of Wisconsin-Madison (D. Gianola) Research stay of U. Ober (UGÖ-TZ), 08/2010-12/2010, co-funded by Synbreed Research stay of A. Ehret (CAU-TZ), 08/2012-12/2012, co-funded by Synbreed





# Achievements









### **Synbreed – meeting the demands:**

Accelerate progress in crop and livestock breeding

Increase the number of highly qualified young breeders

# Strengthen German agricultural research

- international visibility
- competitiveness
- cross linking

- Successful implementation by industrial partners (KWS & Lohmann Tierzucht)
- Currently 23 PhD students from plant/ animal breeding and related fields
- Contributions to international consortia, flanking projects, publications, multispecies research, methodological leadership

# Achievements

## Sustainability of the network

- new professorial chair 'Population Genetics' (S3)
   TUM Center of Life and Food Sciences Weihenstephan
   Prof. Aurélien Tellier
- new professorial chair 'Statistics in Life Sciences' (in progress)
   TUM Center of Life and Food Sciences Weihenstephan
- concentration of expertise at Hans Eisenmann-Zentrum for Agricultural Science TUM Center of Life and Food Sciences Weihenstephan
   → plant breeding, population genetics (S3), biostatistics
- initiation of flanking projects
- collaborations within consortia
- strengthening of German-French collaboration:
  - GEMBAL Multi-breed genomics of beef and dairy cattle
  - Winter school 2012 (population genetics): A. Tellier (S3) + A. Charcosset (SAB)
- interdisciplinary education and training







# Synbreed objectives





Functional analysis of native biodiversity

Genetic analysis of complex traits

Development and implementation of optimal breeding strategies

→ Optimization and implementation of genomic selection and genome-based breeding in maize, chicken and cattle



### **Scientific exchange**

#### University of Wisconsin-Madison

Hans Fischer Senior Fellowship for Prof. Daniel Gianola (2012–2015) Research stay of U. Ober and A. Ehret

#### North Carolina State University

Collaboration on *Drosophila* Genetics Reference Panel using sequence data Research stay of U. Ober

#### Edinburgh University, The Roslin Institute Collaboration on Affymetrix Chip development Research stay of S. Qanbari

 Department of Primary Industries, Melbourne Collaboration on 1000 bull genomes Research stay of M. Erbe, B. Aigner

#### Institut national de la recherche agronomique, INRA Paris, Toulouse Collaboration on allelic diversity in European germplasm Research stay of C. Schön, J. Ertl, M. Gholami

# Cornell University Collaboration on linking allelic diversity in European and US germplasm Research stay of C. Riedelsheimer

- University of California Berkeley
   Research stay of S. Qanbari
- lowa State University
   Research stay of C. Heuer

# Norwegian University of Life Sciences, Norway Collaboration on genomic breeding value estimation in cattle

