UNIKASSEL
VERSITÄT

Improving meat quality in endangered pig breeds using “in vivo” indicator traits

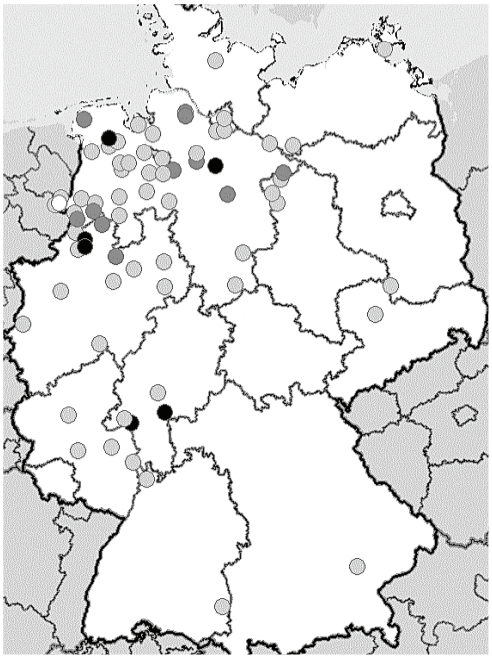
A.D.M. Biermann, T. Yin, K. Rübesam, B. Kuhn, and S. König

Department of Animal Breeding
University of Kassel, 37213Witzenhausen, Germany

Introduction
Population structure of the Bunte Bentheimer pig

UNIKASSEL VERSITÄT

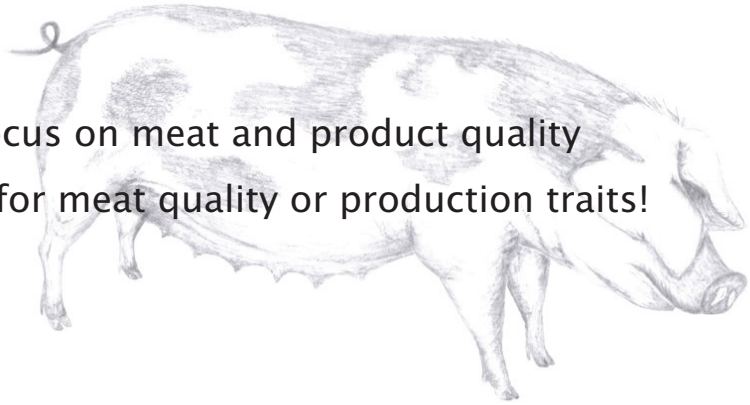
- 333 registered breeding animals (March 2012)
- *Ne* = 30 (based on the rate of inbreeding)
- small-scaled production systems



Biermann et al., 2013

Introduction

UNIKASSEL VERSITÄT



- fatty pig breed
- niche production with focus on meat and product quality
- no performance testing for meat quality or production traits!
- no breeding program!

Motivation:

- performance testing for meat quality adapted to small-scaled production systems
- "in vivo" indicator traits obtained from the selection candidate
  - ultrasound measurements
  - MHS genotype
- evaluation of indicator traits to improve meat quality

Objectives of the study

UNIKASSEL VERSITÄT

1. estimation of genetic (co)variance components for meat quality traits and indicator traits
2. estimation of allele substitution effects for meat quality traits and indicator traits at the MHS locus
3. evaluation of different breeding strategies on meat quality (combination of quantitative-genetic and molecular-genetic approaches)

Material and Methods-
Animals and traits

UNIKASSEL VERSITÄT

- 613 records from selection candidates
- ultrasound measurements using Piglog105 (Carometec Food Technology)
- indicator trait = backfat thickness (**BFiv**)

Material and Methods-
Animals and traits

UNIKASSEL VERSITÄT

- 713 carcass measurements and meat quality traits measured on meat samples
- backfat thickness (BF)
- electric conductivity (EC) 48 h p.m.
- meat brightness (Opto) 48 h p.m.
- drip loss (DL) 48 h p.m.
- intramuscular fat content (**IMF**)

- 700 pigs genotyped at the MHS locus
- indicator trait = MHS as genetic marker

Material and Methods-
Estimation of genetic parameters

UNIKASSEL VERSITÄT

- DMU package (*Madsen and Jensen, 2000*) using AI-REML

$$Y_{ijklmn} = \mu + S_i + H_j + MHS_k + a_l + L_{lm} + b_1 SW_{ijklmn} + e_{ijklmn}$$

Y_{ijklmn}	= observation for production/meat quality traits of the *l-th* pig
μ	= overall mean
S_i	= fixed effect of the *i-th* **sex** of the *l-th* pig
H_j	= fixed effect of the *j-th* **herd** where the *l-th* pig was bred/fattened
MHS_k	= fixed effect of the *k-th* **MHS genotype** of the *l-th* pig
a_l	= random **additive genetic effect** of the *l-th* pig
L_{lm}	= random *m-th* **common environment effect of litter** of *l-th* pig
SW_{ijklmn}	= **weight** at the test/slaughtering date of the *l-th* pig
b_1	= **linear regression** of the production/meat quality trait on the weight at the test/ slaughtering date
e_{ijklmn}	= random residual effect

Results and Discussion-
Variance components and heritabilities

UNIKASSEL VERSITÄT

	Genetic parameters			
Trait	σ^2_a	σ^2_{cl}	σ^2_e	h^2
BF_{iv}	4.85 (2.91)	3.73 (1.10)	9.26 (1.51)	**0.27 (0.06)**
BF	9.12 (3.14)	0.11 (0.83)	9.70 (2.18)	**0.48 (0.04)**
EC	1.59 (0.81)	0.84 (0.30)	2.75 (0.54)	0.31 (0.05)
Opto	6.32 (5.11)	8.68 (2.71)	28.19 (3.57)	0.15 (0.06)
DL	3.44 (1.13)	0.00 (0.24)	3.77 (0.74)	0.48 (0.03)
IMF	0.19 (0.04)	0.04 (0.01)	0.02 (0.02)	**0.78 (0.05)**

Results and Discussion-
Phenotypic and genetic correlations

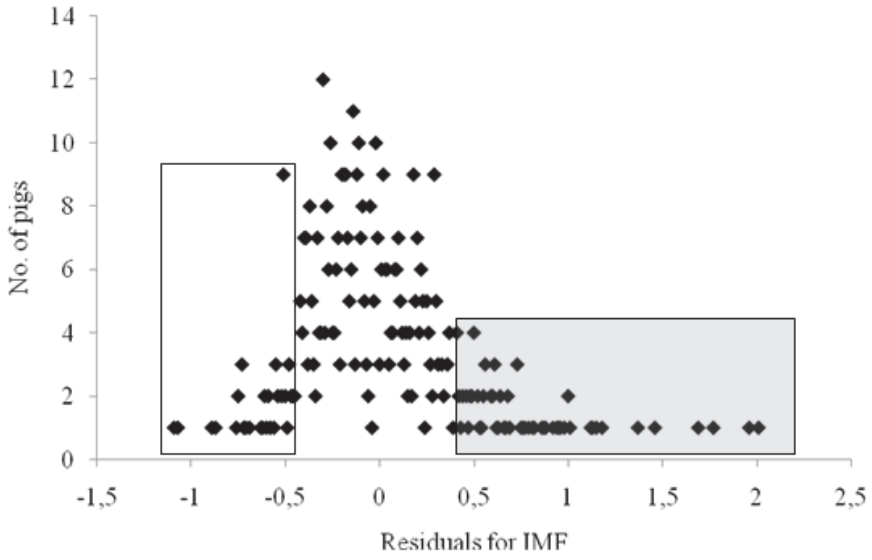
UNIKASSEL VERSITÄT

Traits	BF_{iv}	BF	EC	Opto	DL	IMF
BF_{iv}		**0.96 (0.11)**	-0.06 (0.33)	0.04 (0.44)	-0.09 (0.28)	**0.39 (0.19)**
BF	**0.44^{***}**		0.17 (0.31)	0.07 (0.42)	0.10 (0.27)	**0.25 (0.19)**
EC	0.09^{ns}	0.03^{ns}		0.33 (0.51)	0.52 (0.22)	-0.63 (0.25)
Opto	0.02^{ns}	0.07^{ns}	-0.27^{***}		-0.18 (0.32)	-0.77 (0.30)
DL	0.10^{ns}	0.02^{ns}	0.57^{***}	-0.52^{***}		-0.18 (0.19)
IMF	**0.25^{***}**	**0.24^{***}**	-0.08^{*}	-0.17^{***}	-0.07^{ns}	

Material and Methods-
Estimation of allele substitution effects

UNIKASSEL VERSITÄT

- selection of „extreme phenotypes“ based on residuals for IMF
- 100 animals in each group



Material and Methods-
Estimation of allele substitution effects

UNIKASSEL VERSITÄT

- applying a selective genotyping approach
- methodology based on a logistic model (*Henshall & Goddard, 1999*)
- defining MHS genotype as dependent and binary trait

1. $\text{logit}(\pi_r) = \log\left[\frac{\pi_r}{1-\pi_r}\right] = a + \mathbf{b_1}Yr + S_s + H_t + b_2SW_r$ **2. Allele substitution effect α**

π_r = probability of the genotype NP of a pig r
a = intercept
Y_r = observation for the production/meat quality trait of pig r
b_1 = linear regression of genotype NP on the phenotypic value of the production/meat quality trait
S_s = fixed effect of the s^{th} sex of the pig
H_t = fixed effect of the t^{th} herd of the pig
SW_r = weight at slaughtering date of pig r
b_2 = linear regression of IMF on the weight at the slaughtering date

$$\alpha = \frac{-1 + \sqrt{1 + b_1^2 \sigma_X^2}}{b_1}$$

Results and Discussion-
Allele substitution effects at the MHS locus

UNIKASSEL VERSITÄT

	Difference NP vs. NN		
Trait	α (in general units)	α (in SD units)	b-value[1]
LMC	0.83	0.20	0.05 ns
BF	-0.89	0.19	-0.04 ns
EC	1.70	0.72	0.35 **
Opto	-4.00	0.58	-0.09 **
DL	2.22	0.78	0.32 ***
IMF	**-0.21**	0.42	-0.90 *

- frequency of the alleles: q = 0.13 and p = 0.87
- frequency of the MHS genotypes: NP = 0.23 and NN = 0.76

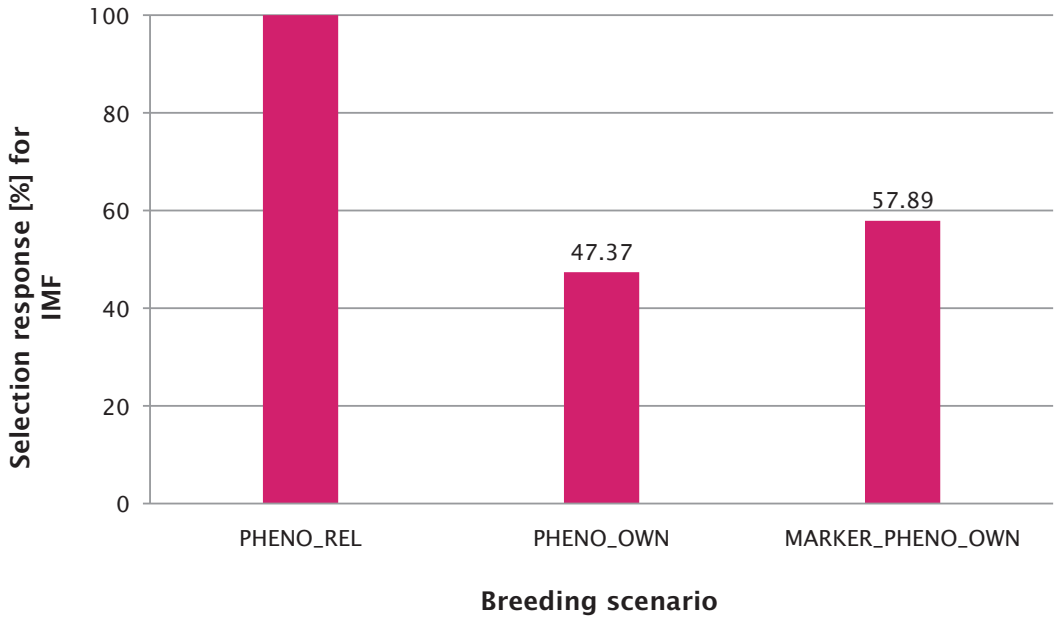
Material and Methods-
Breeding strategies on meat quality

UNIKASSEL VERSITÄT

- selection index theory (implemented in SIG-R (*Pimentel & König, 2012*)
- ultimate breeding goal (100 % meat quality = IMF)
- using quantitative genetic parameter estimates and allele substitution effects for IMF

	Breeding scenario		
	PHENO_REL	PHENO_OWN	MARKER_PHENO_OWN
Information source			 + 
Index traits	IMF	BFiv	BFiv + MHS

Results and Discussion-
Breeding strategies on meat quality (IMF)



Conclusion

UNIKASSEL VERSITÄT

- ✓ ultrasound measurements as performance testing is well adapted to the small-scaled production systems and can easily applied on selection candidates
- ✓ estimates of quantitative genetic parameters and allele substitution effects in the Bunte Bentheimer population reflects estimates in conventional population
  - ✓ valuable tools for breeding programs
- ✓ breeding strategies based on “in vivo” indicator traits improve meat quality in a moderate range
  - ✓ a practical approach to improve meat quality in endangered, small population

Conclusion

UNIKASSEL VERSITÄT

- ✓ ultrasound measurements as performance testing is well adapted to the small-scaled production systems and can easily applied on potential selection candidates
- ✓ estimates of quantitative genetic parameter and allele substitution effects in the Bunte Bentheimer population reflects estimates in conventional population
  - ✓ valuable tools for breeding programs
- ✓ breeding strategies based on “in vivo” indicator traits improve meat quality in a moderate range
  - ✓ a practical approach to improve meat quality in endangered, small population

Thank you for your attention!

The project is funded by the Federal Office for Agriculture and Food (BLE) and the Landwirtschaftliche Rentenbank

Descriptive statistics

UNIKASSEL VERSITÄT

Trait	Unit	N	Mean	SD	Min	Max
BF_{iv}	[mm]	613	24.31	5.69	6.00	39.00
BF	[mm]	503	31.68	4.73	17.00	48.98
EC	[mS/s]	674	6.52	2.36	1.20	9.93
Opto	[0=bright; 90=dark]	679	74.18	6.96	49.43	89.50
DL	[%]	657	4.80	2.86	0.80	18.76
IMF	[%]	686	1.57	0.49	0.77	3.99