Genetic Analysis of Feather Pecking and Mortality in Laying Hens

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Introduction

- About 8-10 % total mortality of birds until 80 weeks of age
- Minimizing bird losses is important
  - from an economical point of view
  - from the animal welfare point of view
- Mortality as a compound trait, is highly dependent on environmental conditions and also depends on social interactions with other birds
- A high level of feather pecking has been found to be correlated with high mortality from cannibalism

D. Bell, 2012

Introduction

- **Feather pecking is one of the most obvious welfare problems in laying hens**

- **Observed in all types of housing systems for commercial laying hens**

  - **Feather damage**
  - **Increase of food consumption for higher maintenance energy requirement**
  - **Skin injury and infection diseases**
  - **Mortality**

Kjaer und Mench, 2003

Introduction

Feather pecking

is a multifactorial problem caused by both genetic and environmental factors

Genetics

- Breed and lines
- Layer vs. Broiler
- Selection for high egg production
- Early sexual maturity
- Low body weight

Environments

- Group size
- Light intensity
- Diet and feed structure
- Type of litter
- Ambient temperature

Kjaer und Mench, 2003, F. Biscarini, 2010

Goals

- **The objective of this research work is to estimate genetic parameters of mortality and feather cover score**

- **Genome wide association study based on a Genome-Wide Chicken Array to identify SNPs and genes associated with affromentiond traits**

Material and Methods

Animals and husbandry

- Brown layer hens kept under cage systems
- 3 different cage sizes
- 3 to 13 hens from one sire per cage

  - Number of hens: 32523
  - Number of sires: 538
  - Number of cages: 5337

Material and Methods

Animals and husbandry

Aggressor and victim in one family

Material and Methods

Recording of phenotypic traits

- **Feather pecking behaviour**
  - ***Plumage condition at the age of 45 and 70 weeks***
    - ***Feather score: 1 (low plumage quality) to 9 (high plumage quality)***

- **Mortality**
  - ***Cumulative until 45 weeks of age (%)***
  - ***and from 46 to 70 weeks of age (%)***

- **Performance traits**
  - ***Egg performance (g/d) at the age of 45 and 70 weeks***

Material and Methods

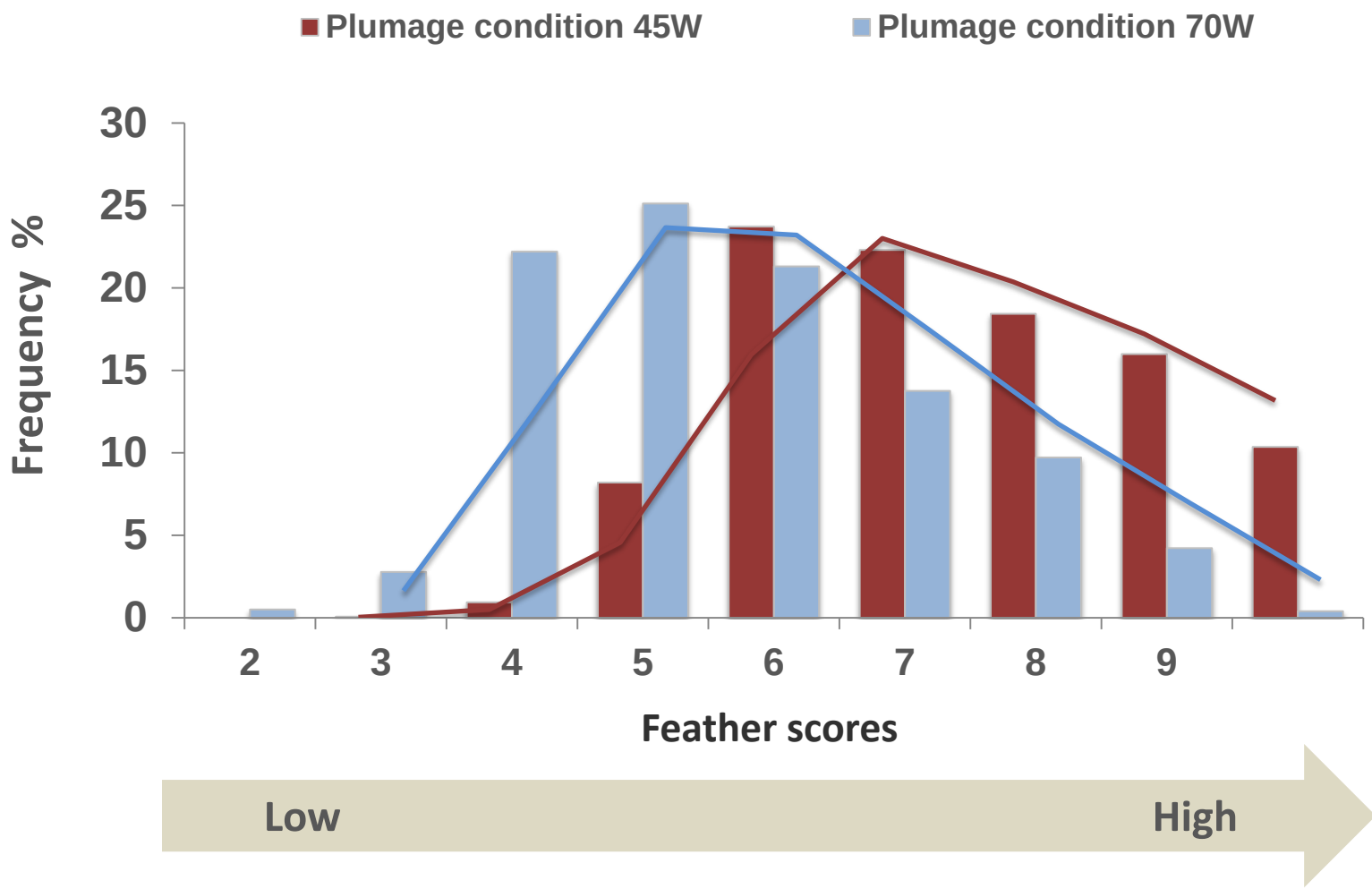
Bivariate analysis using sire model for estimation of genetic parameters

$$y_{ijklmn} = \varphi + \alpha_i + \alpha\beta_{ij} + \lambda_k + \gamma_l + \rho_m + \varepsilon_{ijklmn}$$

y= Plumage condition, Mortality

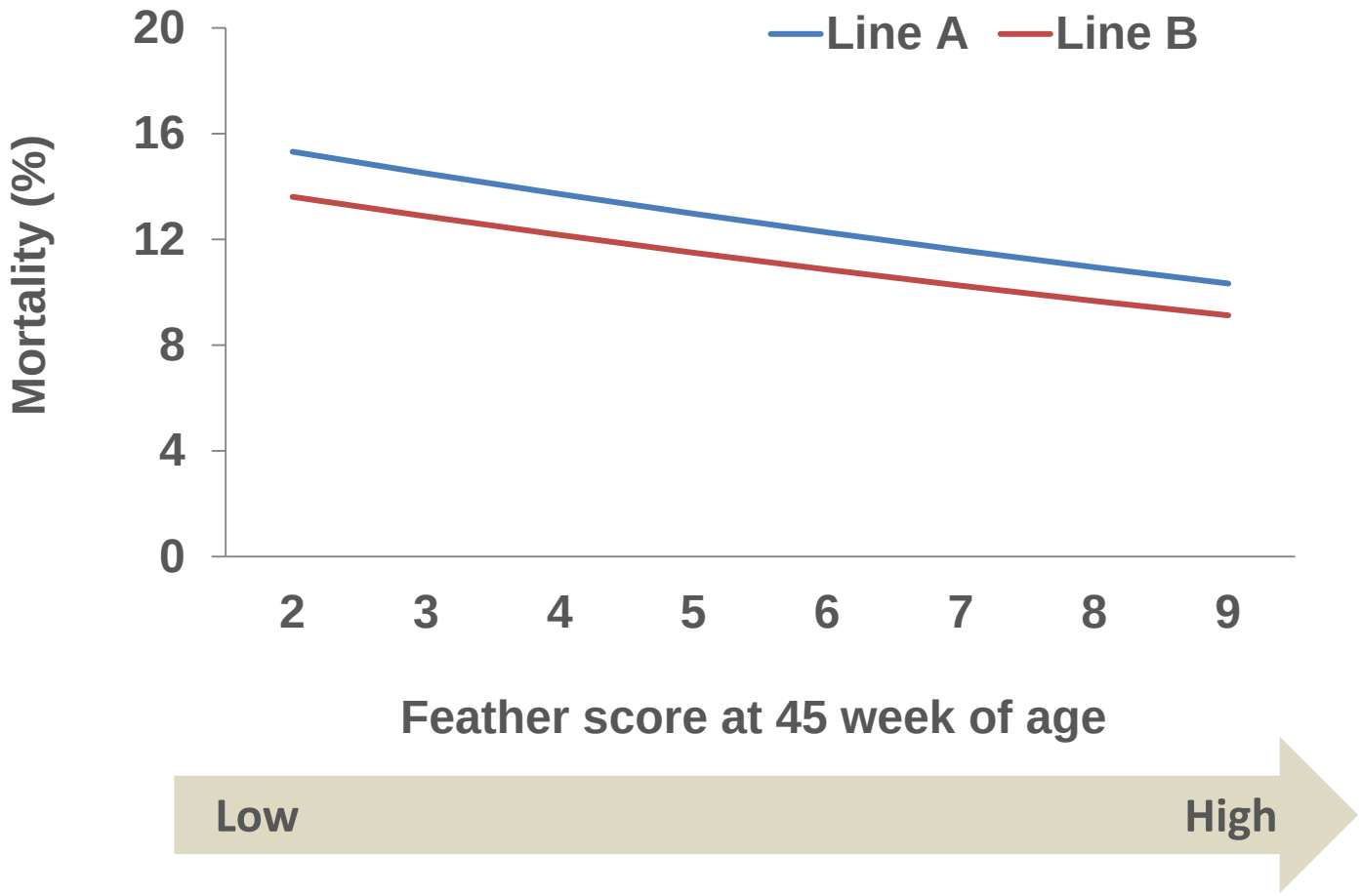
φ= Overall mean effect
α_i= Fixed effect of poultry house
β_j= Fixed effect of tier+site+lane
λ_k= Fixed effect of breeding line
γ_l= Random effect of sire
ρ_m=Random effect of common environment
ε_{ijklmn}=Is random residual effect

Results


Plumage condition 45W
Plumage condition 70W
Frequency %
30
25
20
15
10
5
0
2
3
4
5
6
7
8
9
Feather scores
Low
High

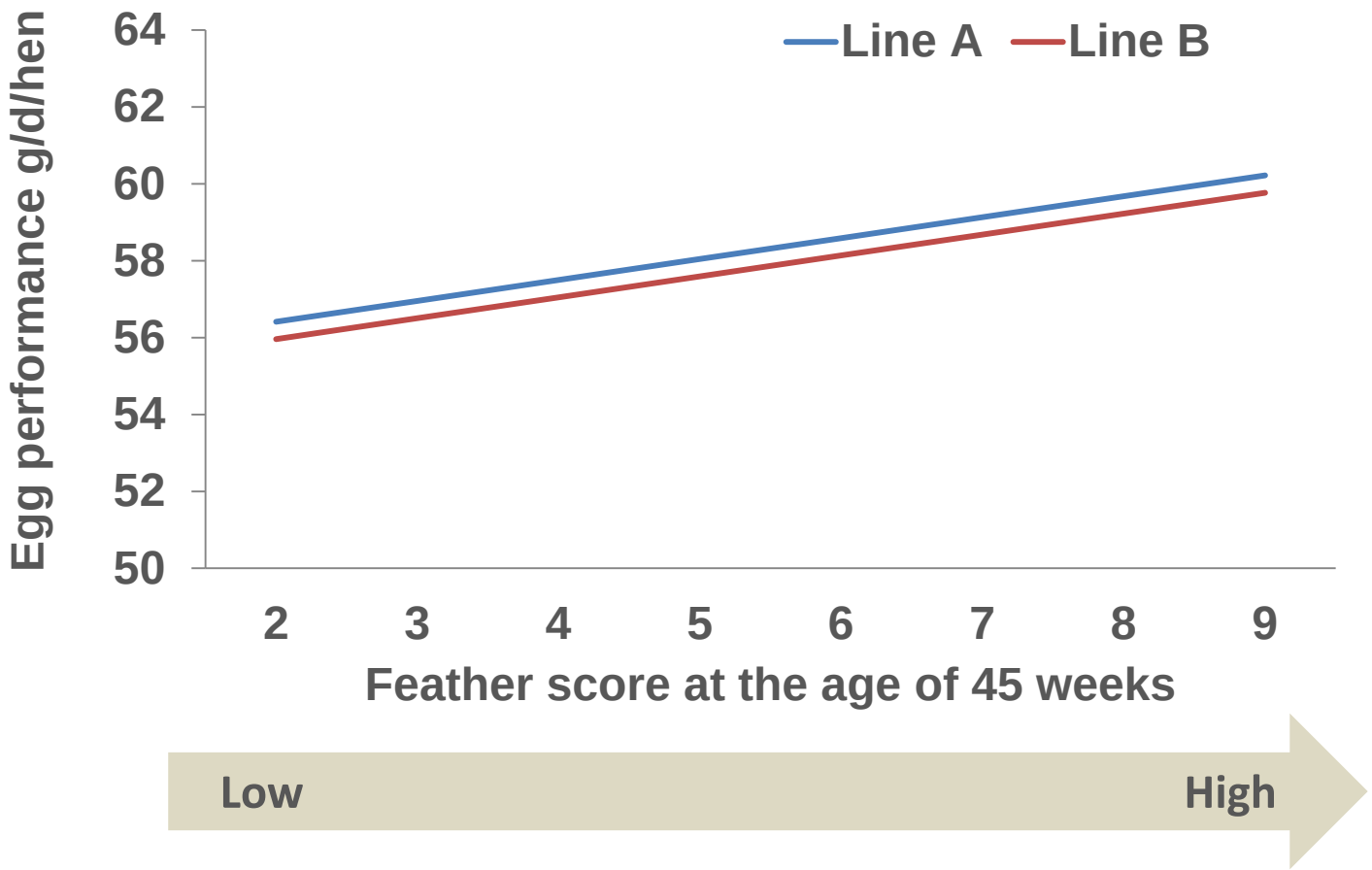
Results

The effect of Plumage condition on mortality



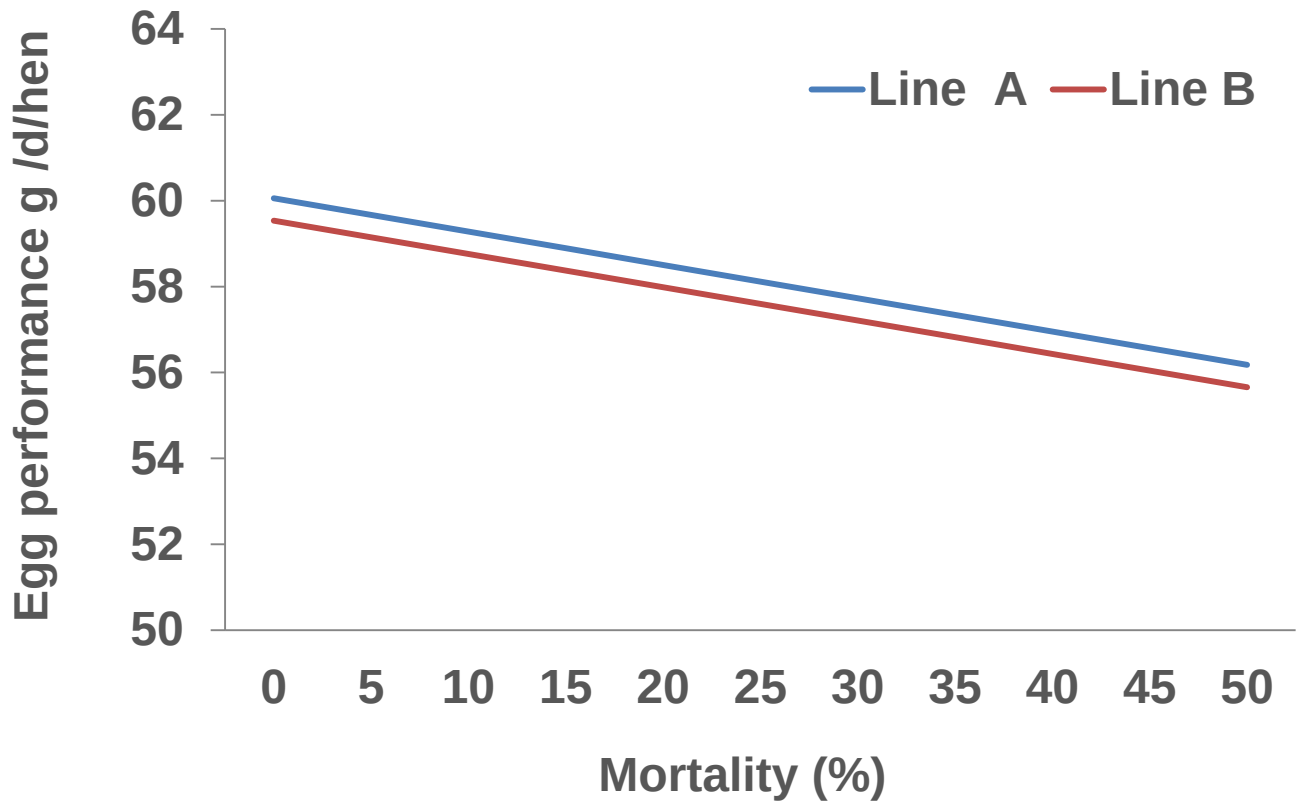
Results

The effect of feather score on egg performance



Results

The effect of mortality on egg performance



Results

Estimation of genetic parameters for mortality and plumage condition at the age of 45 weeks using a bivariate analysis (sire model)

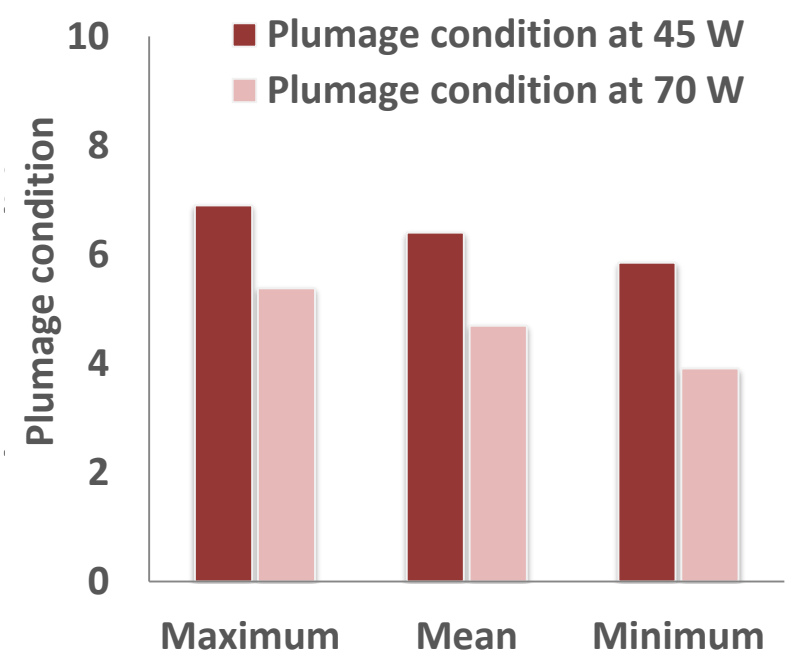
Traits	Mortality	Plumage condition
Mortality	0.20 (0.007)	-0.22 (0.156)
Plumage condition		0.29 (0.019)

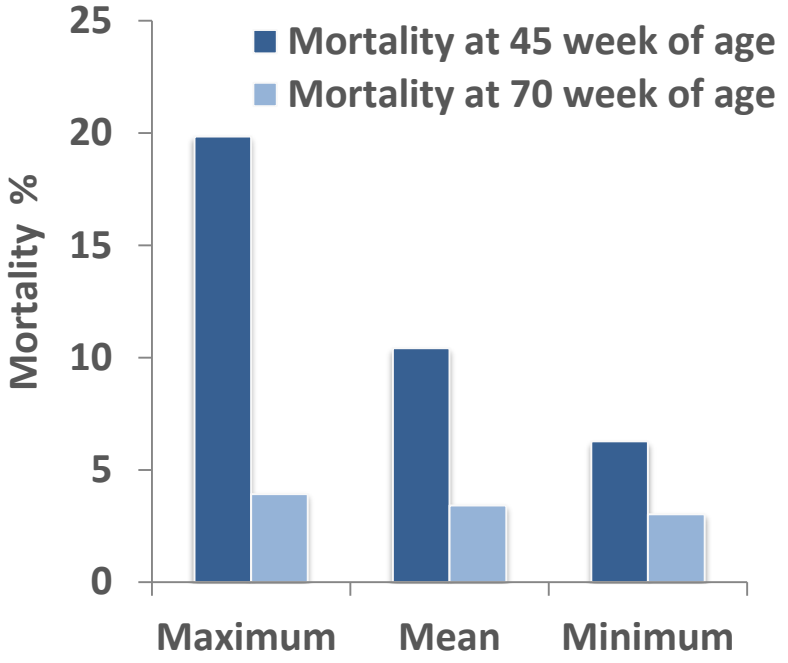
Results

Estimation of genetic parameters for mortality and plumage condition at the age of 70 weeks using a bivariate analysis (sire model)

Traits	Mortality	Plumage condition
Mortality	0.019 (0.004)	0.24 (0.375)
Plumage condition		0.080 (0.024)

Results





Mean, minimum and maximum of breeding values for mortality and feather score

Further analyses

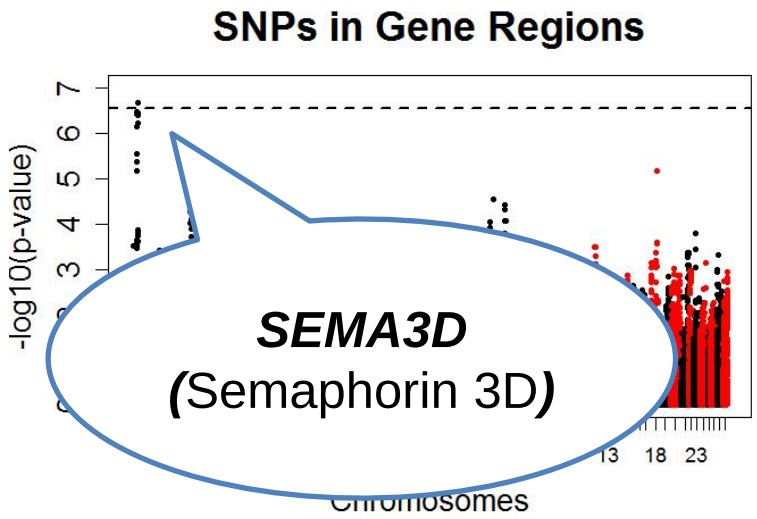
- **Based on the results (breeding values) from the bivariate analysis of mortality and feather score:**

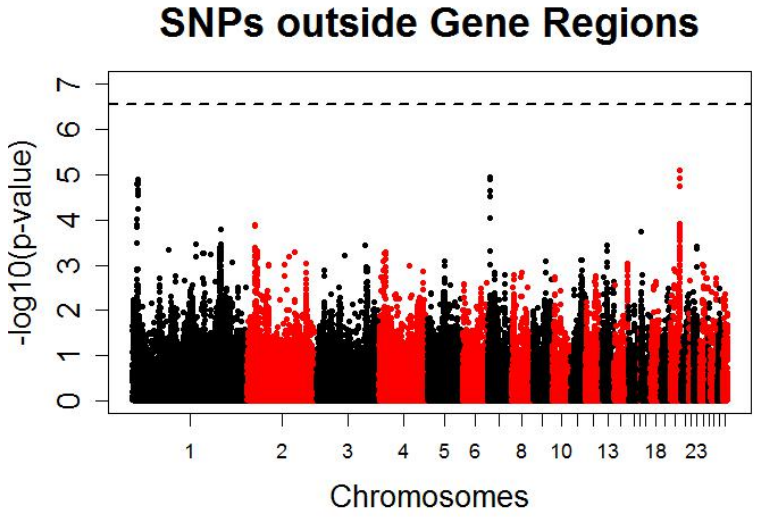
→ **Genome-wide association study**

- **Genomic data:**
  - 296 cocks genotyped with Affymetrix Axiom® Genome-Wide Chicken Array
  - ~ 335.000 SNPs on autosomal chromosomes after quality checks
- **Model : Single Marker Regression (with correction for stratification in the population)**

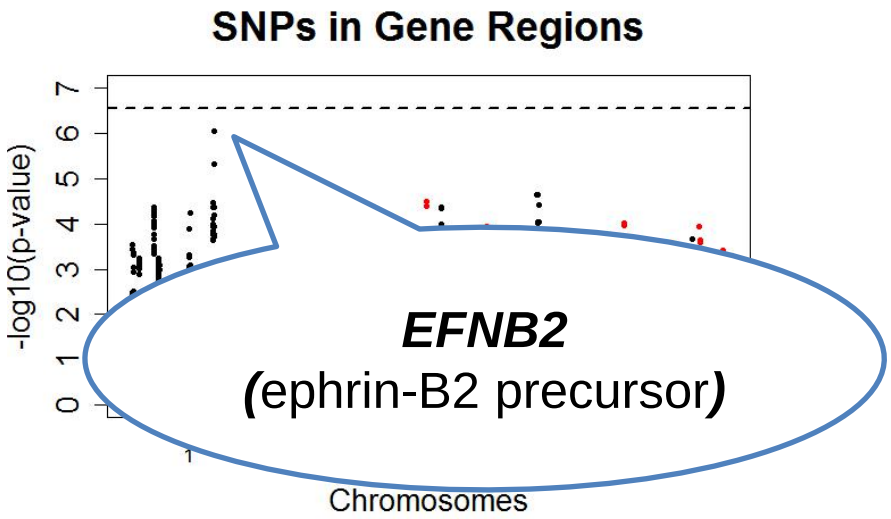
Results

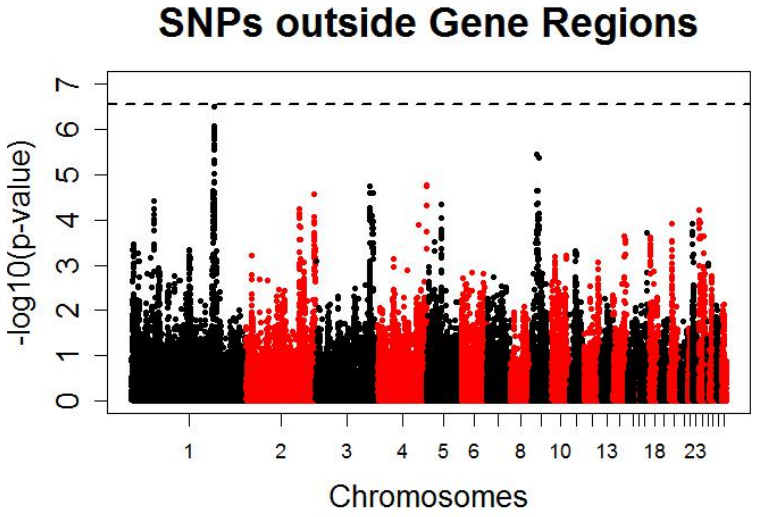
Mortality





Plumage condition





Conclusions

- Estimated heritabilities for mortality and plumage condition were low to moderate
- Selection for good plumage condition result in higher liveability and performance
- Even though the heritability is low, high reproductive performance and low generation interval in chicken make it feasible to select animals successfully for higher plumage condition (feather pecking) and survival ability
- GWAS resulted in the detection of two candidate genes SEMA3D and EFNB2

Thank you very much for your attention

Material and Methods

Genome-wide association study

- **Data:**
  - 296 cocks genotyped with Affymetrix Axiom® Genome-Wide Chicken Array
  - ~ 335.000 SNPs on autosomal chromosomes after quality checks
  - Breeding values for mortality and feathering

- **Model :** **Correction for stratification by including effects for principal components (70% variation explained)**

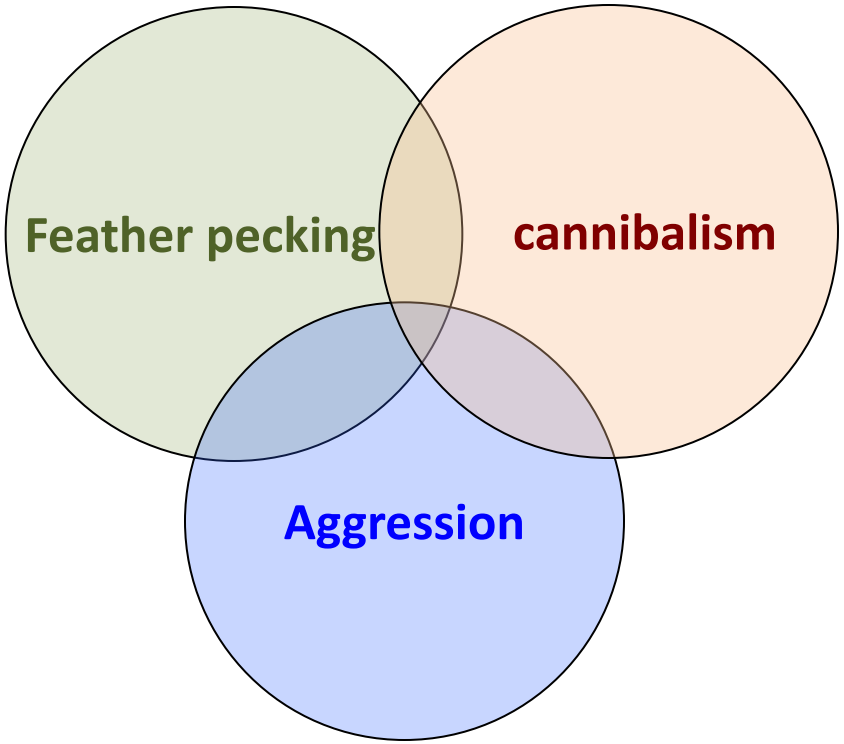
  y=Xb+Wu+e

  with
  y = breeding values
  X = design matrix for single marker regression
  W = design matrix for fixed PC effects
  b = vector with intercept and regression coefficient
  u = vector with fixed PC effects
  e = vector of random residual effects with $e \sim N(0, I\sigma_g^2)$

Introduction

Feather pecking, cannibalism and aggression (AG) are supposed to have different motivational backgrounds

The causes of feather pecking are multi-factorial

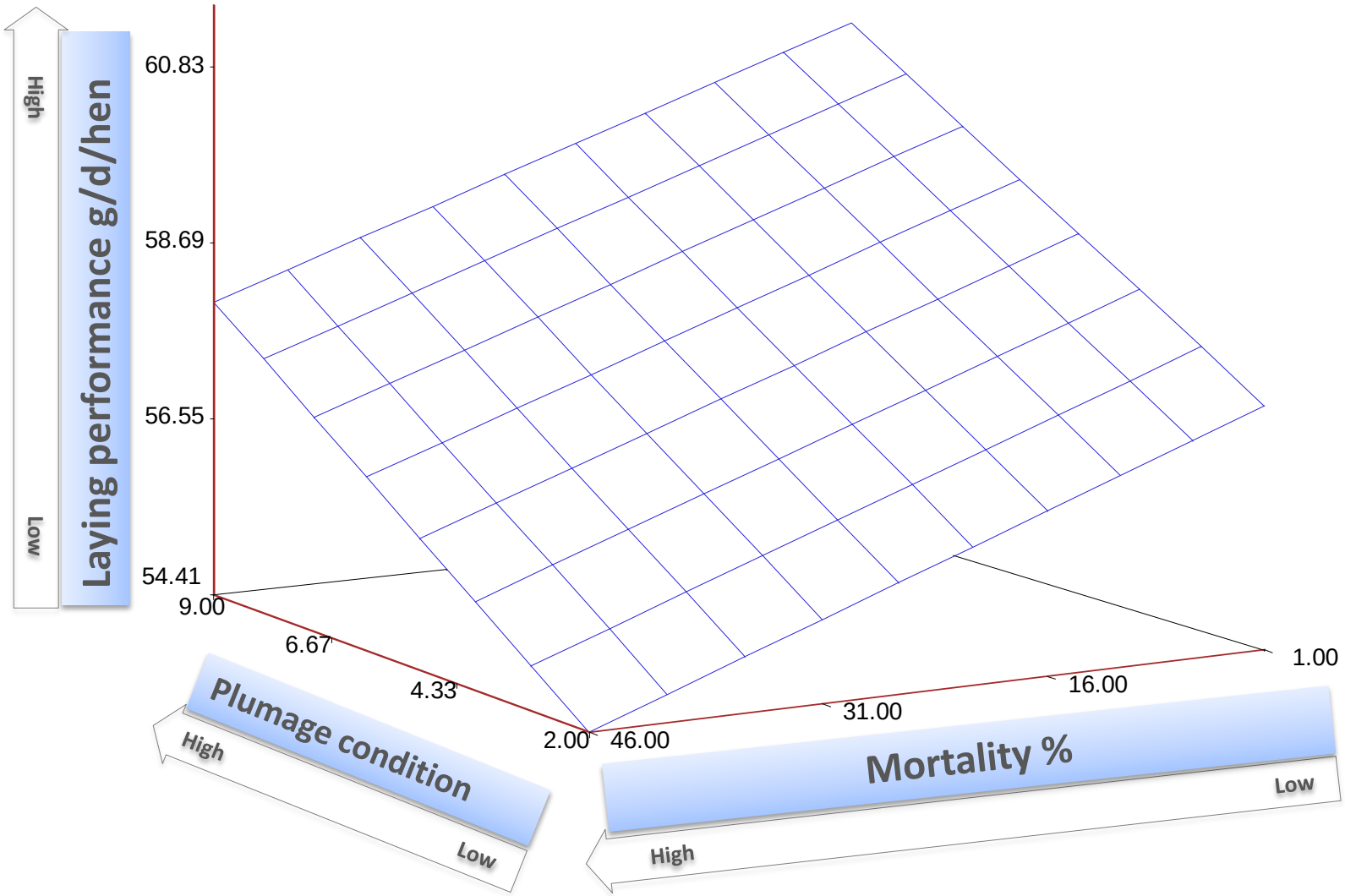


Nevertheless some interactions occur, where one behaviour leads to another, indicated by the overlapping areas.

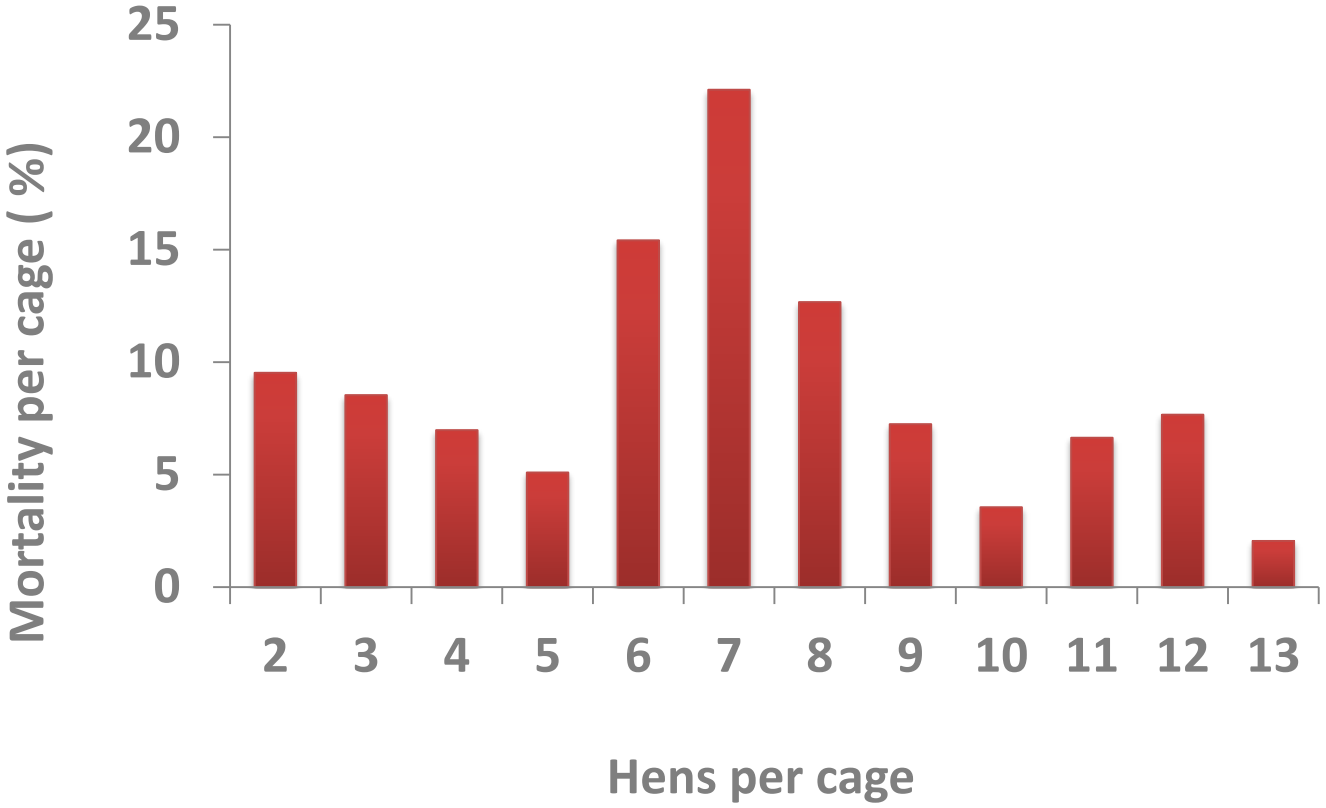
Kjaer und Mench, 2003

Result

The effect of Plumage condition on mortality and performance



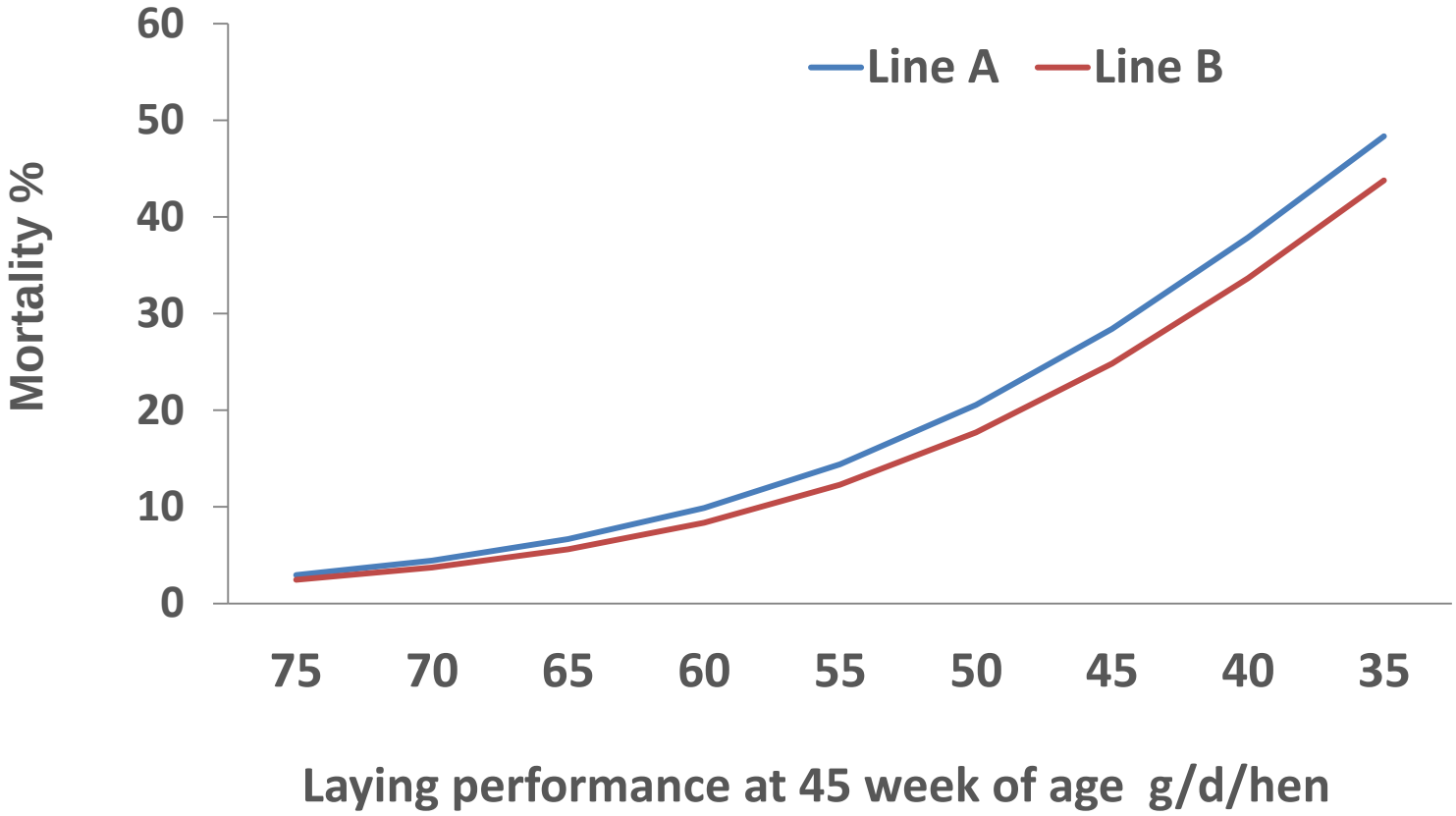
Result



The effect of cage density on total morality

Result

The association between of laying performance and mortality



Result

Estimation of genetic parameters for mortality , plumage condition and egg performance at 45 week of age using a multivariate analysis (sire model)

Traits	Mortality	Plumage condition	Egg performance
Mortality	0.15 (0.007)	-0.2289	-0.127
Plumage condition		0.355 (0.019)	0.125
Egg performance			0.2041

Result

Estimation of genetic parameters for mortality , plumage condition and egg performance at 70 week of age using a multivariate analysis (sire model)

Traits	Mortality	Plumage condition	Egg performance
Mortality	0.15 (0.004)	0.17 (0.300)	0.21 (0.266)
Plumage condition		0.29 (0.020)	0.074 (0.118)
Egg performance			0.24 (0.017)

Introduction

- mortality is caused is caused by diseases agents and parasites
- injuries through aggression, flightiness, feather pecking and cannibalism under stressful environmental situation such as caging of birds in commercial multiple bird cages (Graig and Muir, 1996; Muir, 1996)
- A high level of feather pecking has been found to be correlated with high mortality from cannibalism

Graig and Muir, 1996; Muir, 1996)

Goals

A group selection (Graig and Muir, 1996; Muir, 1996) based on mortality and other indirect traits such as injury occurrence (analysed as either a binary or an ordered categorical trait) and feather cover score can be performed, provided that these traits are heritable and correlated to mortality

Kjaer und Mench, 2003

Material and Methods

Statistical model for estimation of genetic parameters (univariately using generalized sire model)

$$Logit(\pi_{rstv}) = \eta_{rstv} = log(\pi_{rstv} / 1 - \pi_{rstv}) = \varphi + \alpha_r * \beta_s * \lambda_t + \gamma_v + \rho_v$$

η_{rst}= linear predictor

π_{rst} = Probability of fertility; or probability of hatchability for fertile eggs, or probability of EEM,MEM and LMM

φ = Overall mean effect
α_r = Fixed effect of poultry house
β_s = Fixed effect of tier+site+lane
λ_t = Fixed effect of brrding line
ρ_v = Random effect of common environment sire

Material and Methods

- **Genomewide association study**
  - 296 cocks genotyped with Affymetrix Axiom® Genome-Wide Chicken Array
  - ~ 335.000 SNPs on autosomal chromosomes after quality checks
  - Breeding values for mortality and feathering
- **Model I:** **Mixed model approach: Single Marker Regression with correction of polygenic effects**

  y=Xb+Zg+e

  with
  y = breeding values
  X = design matrix for marker regression
  Z = design matrix for random polygenic effect
  b = vector with intercept and regression coefficient
  g = vector of random polygenic effects with $g \sim N(0, G\sigma_g^2)$
  e = vector of random residual effects with $e \sim N(0, I\sigma_g^2)$
  G = genomic relationship matrix

Material and Methods

Means, minimum and maximum of different trials	
Number of hens per sire	6.07 (2-13)
Plumage condition at 45 weeks of age	6.08 (2-9)
Plumage condition at 70 weeks of age	4.67 (1-9)
Mortality (at 45 and 70 weeks of age)	11.0 (0-100)