Longitudinal analysis of residual feed intake in mink using random regression with heterogeneous residual variance

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Mink Breeding

• Denmark:
  
  • World second mink fur producer
    
    • 17.2 Million skin (2012-2013)
  
  • Fur farming is Denmark's third largest type of animal farming
Mink Fur Production and Price

Denmark world second largest mink skin producer
Fur skins are Denmark's largest export commodity to China
Mink breeders & feed efficiency

• **Mink breeders:**
  - Include feed efficiency in mink breeding program

• **Improvement in efficiency:**
  - Increased compatibility of fur production
    - 40-50% skin cost
  - Reduced nutrient excretion (environmental pollution)

<table>
<thead>
<tr>
<th>Year</th>
<th>Feed produced, t</th>
<th>Protein of feed, t</th>
<th>Nitrogen of feed, t</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 - 2013</td>
<td>801.891</td>
<td>123.501</td>
<td>19.760</td>
</tr>
</tbody>
</table>
Feed intake
Dissect the genetic background of longitudinal residual feed intake (RFI) and body weight (BW)

- Accurate method for feed efficiency
- Least phenotype recording
Data

• 2139 cages
  • Pairs of one male and one female

• Cumulative feed intake per cage
  • 6 measurements
  • From 105 – 210 days of age (15 to 30 weeks of age)
  • Every three weeks

• Body weight per animal
  • 8 measurements
  • From 63 – 210 days of age (9 to 30 weeks of age)
  • Every three weeks
Body weight and feed intake curve

Growing-furring period, days

BW, kg

Cumulative FI, kg

Growing

Furring

Male BW
Female BW
Cumulative FI
• Univariate models

• Random Regression
  • Legendre polynomials

• Gibbs Sampling
Random regression-Legendre polynomials

**RFI** Male & Female

\[ CFI \text{ cage}_{ijklm} = YL_i + b_1(BW_{Male \, k}) + b_2(BW_{Female \, l}) + l_{q1}(t)'r_i \quad \text{Fixed part, LP}_0, \, LP_1, \, LP_2 \]

\[ + l_{q2}(t)'a_k \quad \text{Male, LP}_0, \, LP_1 \]

\[ + l_{q2}(t)'a_l \quad \text{Female, LP}_0, \, LP_1 \]

\[ + l_{q2}(t)'p_k \quad \text{Male PE, LP}_0, \, LP_1 \]

\[ + l_{q2}(t)'p_l \quad \text{Female PE, LP}_0, \, LP_1 \]

\[ + e_{ijklm} \quad \text{Heterogeneous, 6 levels} \]

**G = 4 \times 4**

**P = 4 \times 4**
Random regression-Legendre polynomials

- \textbf{BW}_{\text{male}} & \textbf{Bw}_{\text{female}}

\[ y_{ijkm} = YL_i + l_q(t)'r_i \quad \text{Fixed part, LP}_0, \text{LP}_1, \text{LP}_2 \]

\[ \textbf{G} = 3 \times 3 \quad + l_q(t)'a_k \quad \text{Genetic effect, LP}_0, \text{LP}_1, \text{LP}_2 \]

\[ \textbf{P} = 3 \times 3 \quad + l_q(t)'p_k \quad \text{PE, LP}_0, \text{LP}_1, \text{LP}_2 \]

\[ + e_{ijkm} \quad \text{Heterogeneous, 8 levels} \]
Genetic background of RFI

![Graphs showing heritability over growing-furring period for males and females.](image-url)
Phenotypic variance of RFI

Growing-Furring period, days

Phenotypic variance

Male
Female
Genetic correlations among RFI

![Graph showing genetic correlations]
Phenotypic correlations among RFI
Genetic background of BW
Phenotypic variance of BW

Growing-Furring period, days

Phenotypic variance

Male
Female
Genetic correlations among BW
Phenotypic correlations among BW
Selection index theory

- Accuracy of selection based on different recording strategies

\[ r_{a,I} = \frac{\sqrt{b' P b}}{\sqrt{a' G a}} \]

- \( r_{a,I} \) = accuracy of index
- \( b \) = \( n \times 1 \) vector of weighing factors for each record
- \( P \) = \( n \times n \) matrix of phenotypic (co)variance among records of each trait
- \( a \) = \( n \times 1 \) vector of relative economic values for each record with only the pelting RFI and BW (210 days) considered to have one economical weight and other time points to be zero
- \( G \) = \( n \times n \) matrix of genetic (co)variance among all records of each trait
Selection Indices

RFI

BW

Accuracy

Scenarios

0.66 0.67 0.68 0.69 0.70 0.71 0.72 0.73 0.74 0.75 0.76

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105 126 147 168 189 210

63 84 105 126 147 168 189 210

Accuracy

Scenarios

0.91 0.915 0.92 0.925 0.93 0.935 0.94 0.945

0.91 0.915 0.92 0.925 0.93 0.935 0.94 0.945

105 126 147 168 189 210

63 84 105 126 147 168 189 210

\( r_{ai} \) Male

\( r_{ai} \) Female

\( r_{ai} \) Male

\( r_{ai} \) Female
Conclusion

Feed efficiency can be improved substantially by selection at the later stages of growth

Different genes can be associated with feed efficiency and body weight during the growing-furring period

Random regression models are suitable for dissecting the genetic background of RFI & BW