Statistical tools to detect genetic variation for a sex dimorphism in piglet birth weight

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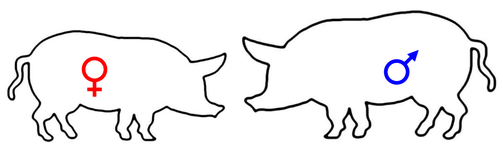
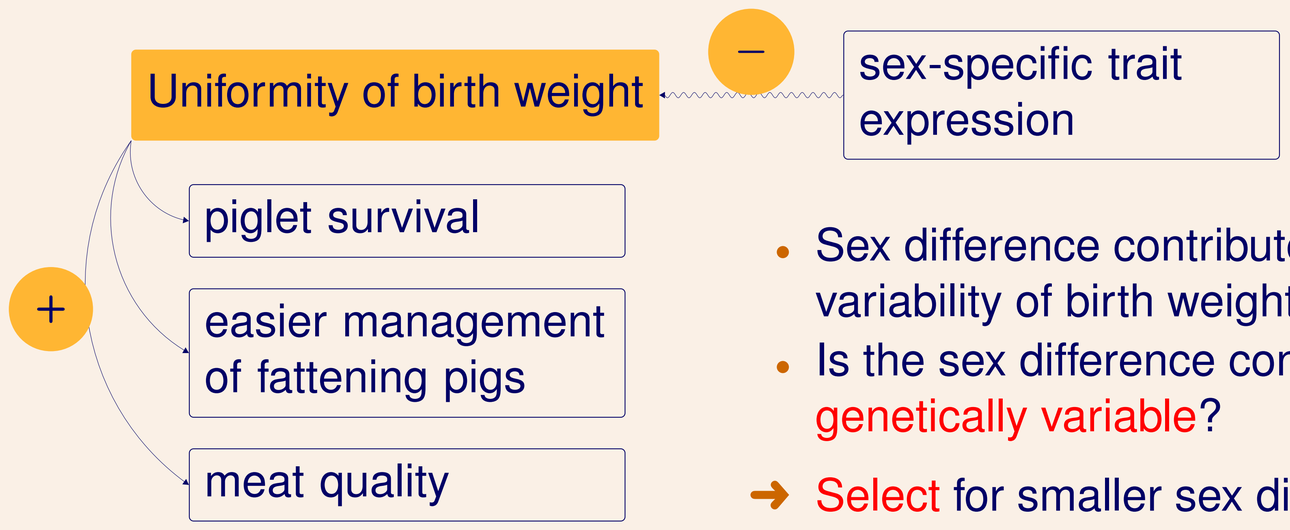
The old story…



…male piglets are heavier and more variable at birth than females.

Motivation and Problem

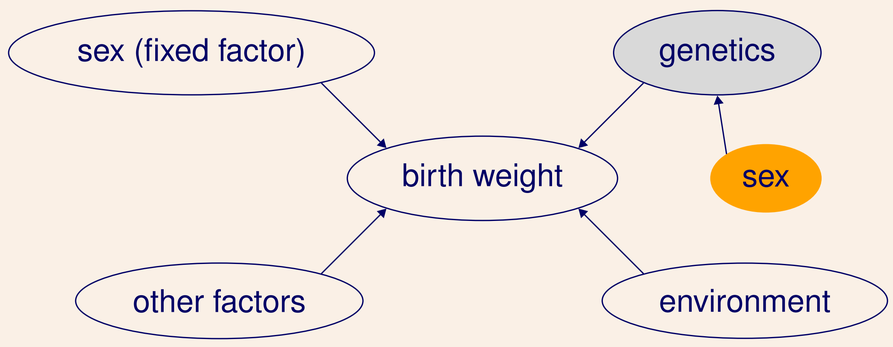


- Sex difference contributes to within-litter variability of birth weight.
- Is the sex difference constant or genetically variable?

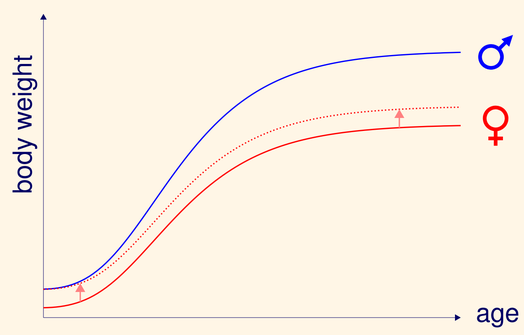
➜ Select for smaller sex difference (i.e. smaller within-litter variance).

Approach

Distinct breeding values for male and female birth weight. Are they different?



Conclusions

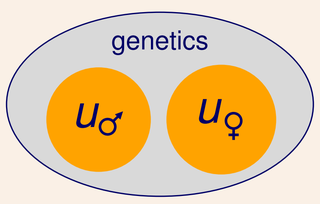


- Sex difference in birth weight is genetically variable.
- Y-chromosome is involved.
- Heritability is small (3–4 %).

➜ Breeding to increase uniformity at birth may reduce sex difference in later ages.

Theory

❶ Animal model with genetic effect differing between sexes

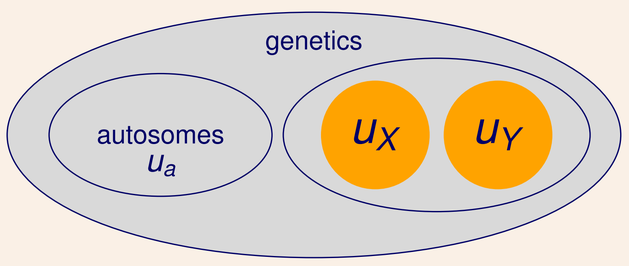


$$\mathrm{Cov}(\boldsymbol{u}_♂, \boldsymbol{u}_♀) = \boldsymbol{A}\sigma_{♂,♀}$$
$$\sigma_{♂,♀} = \rho\, \sigma_♂ \sigma_♀$$

H_0: $\rho = 1$ and $\sigma^2_♂ = \sigma^2_♀$

A: numerator relationship matrix
S: relationship for X-chromosomal loci

❷ Pedigree approach with effect of sex-linked genes



$$u_♂ = u_a + u_X + u_Y$$
$$u_♀ = u_a + u_X$$
$$\mathrm{Var}(\boldsymbol{u}_X) = \boldsymbol{S}\sigma^2_X,\ \mathrm{Var}(\boldsymbol{u}_Y) = \boldsymbol{I}\sigma^2_Y$$

$H_0^{(1)}$: $\sigma^2_Y = 0$ or $H_0^{(2)}$: $\sigma^2_X = 0$

Measure of heritability

- Difference in genetic effect
  $u_♂ - u_♀$
- Difference in phenotype
  $T_♂ - T_♀$

➜ Heritability

$$h^2 = \frac{\mathrm{Var}(u_♂ - u_♀)}{\mathrm{Var}(T_♂ - T_♀)}$$

Data

- Landrace (LR): 57 647 piglets
- Large White (LW): 45 619 piglets
- Pedigree with $\leq$ 11 generations

Null distribution of the test statistic was approximated as a mixture of χ^2-distributions.

Results

- Genetic correlation ρ was close to one.
- Breeding values significantly differed in line LR ($p = 0.004$) but not in LW ($p = 0.099$).
- Y-chromosomal effect was significantly present in line LR ($p < 0.001$) and also in combination of model ❶ & ❷ ($p = 0.022$).

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