Genome wide association study for number of teats and inverted teats in Norsvin Landrace pigs

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Background

- The number of functional teats in the sow is important in order to provide enough teats for larger litters.
- Every piglet born should be weaned by own mother
- Counted on all piglets at 3 weeks of age
- Included in the breeding goal from 2001
Phenotype #teats

- Mean teat number in Norsvin Landrace is 15.4 (SD=1.04)
  - Minimum of 10, maximum of 25
  - Heritability is 0.42
Teat quality is also important and inverted teats are of less value for producers selling sows and some inverted teats can have reduced milk flow.

Boars: registered at 120 kg, sows: registered at field test 5 months

Included in the breeding goal from 2012
Phenotype #inverted teats

- Mean number of inverted teats is 0.67 (SD=1.76) and 0.82 (SD = 2.03) for boars (B) and sows (S)
  - Minimum is 0 for both, maximum is 16 (B) and 18 (S)
  - Heritability is 0.32 (B) and 0.3 (S)
Aim: Detect QTL affecting number of teats and inverted teats in the Norsvin Landrace population.
Animals

- 5651 pigs included with breeding values estimated for:
  - Total number of teats, corrected for fixed effects of heardyear and sex and random effects of litter and animal
  - Inverted teats for boars, corrected for fixed effects of heardmonth and random effect of animal
  - Inverted teats for sows, corrected for fixed effects of heardyear and sex, fixed regression of weight and random effects of litter and animal

- Genotypes were included in a genomic relationship matrix (DMU, GMATRIX) together with phenotypes and pedigree using a single-step method (DMU, PGMIX)
Methods

- Illumina 60k chip
  - 37,244 mapped SNPs (Build10.2) passed quality control
  - MAF > 0.01, call rate > 0.95, error rate < 0.01

- Beagle used to impute sporadically missing genotypes

- GWAS was conducted using R package GenABEL (Aulchenko)
  - structured association approach (Cochran-Armitage test)

- The p-values were corrected for genomic control (GC) of a 1-df test

- GC-corrected p-value < 0.0001 considered significant
GWAS number of teats

- 50 significant SNPs, two QTL regions

SSC7 = Duijvesteijn et al., Ding et al., Guo et al., Sato et al.

SSC14: EDAR-associated gene (EDARADD), required for normal development of mammary glands, Hair follicles, teeth, sweat glands
SSC7 number of teats
SSC7 number of teats

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<table>
<thead>
<tr>
<th>Year</th>
<th>Freq.(B)</th>
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<tbody>
<tr>
<td>2011</td>
<td>0.695</td>
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<tr>
<td>2012</td>
<td>0.710</td>
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<tr>
<td>2013</td>
<td>0.721</td>
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<td>2014</td>
<td>0.777</td>
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GWAS number of inverted teats, boars

1 significant SNP on SSC1:
Intergenic region between genes LOC102162094 – ANKS6

ANKS6
- Associated with dental anomalies in human
GWAS number of inverted teats, sows

SSC1: close to KANK1, gene involved in regulation of wnt signaling
- important for teat development in mice
Conclusions number of teats

- Significant QTL for number of teats found on SSCs 7 and 14

- SSC7 QTL previously characterized in other breeds and is now confirmed in Norsvin Landrace
  - Overlap with QTL and gene for number of vertebrae
  - Sequencing needed to identify causal variant

- SSC14 QTL
  - Not previously identified
  - Role of candidate gene should be investigated

Photo: Kjersti Wold, Norsvin
Conclusions number of inverted teats

- One significant SNP for number of inverted teats registered on boars
  - Role of candidate gene should be investigated
- No significant SNPs for number of inverted teats registered on sows