Associations of Gilt Body Composition, Growth and Structural Soundness Traits with Sow Lifetime Reproductive Performance

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Summary and Implications

The purpose of this study was to estimate the genetic parameters for body composition, growth, structural soundness and lifetime reproductive traits in commercial females. The study involved 1,447 females from two commercial genetic lines. Analyzed traits included loin muscle area, backfat, days to 113.5 kg body weight, 6 body structure traits, 5 leg structure traits per leg pair, overall leg action, length of lifetime (L), percentage non-productive from total herd days (NPD%), lifetime number born alive (LBA) and number born alive per lifetime days (LBA/L). The heritability estimates were obtained with multiple trait animal models. The estimates were high for growth and body composition traits and low to moderate for structural soundness traits and lifetime reproductive traits. The genetic correlations were estimated using bivariate animal models. Most of the genetic correlations of growth, body composition and soundness traits with lifetime reproductive traits were low and non-significant ($P > 0.05$). In general, loin muscle area and body structure traits had a non-significant trend of being favorably associated with lifetime reproductive traits, while an unfavorable trend was observed in the associations of backfat and days to 113.5 kg body weight with lifetime reproduction. The strongest associations with lifetime reproductive traits were obtained for days to 113.5 kg body weight, body length, rib shape, turned front legs and upright rear legs. <u>However, these results need to be interpreted within the distributions of observations present in the dataset.</u> Females with closer to intermediate growth rate to 113.5 kg (range 144 - 227 days, 84 % of females reaching the weight by 190 days of age), intermediate body length (89% of observations divided into scores 4 - 6, 5 describing intermediate length), more shaped ribs (observations close to normally distributed over the 9-point scale), slightly outwards turned front legs (after transforming records to deviations from optimum, 79% of observations distributed into two best scores) and less upright rear legs (after separating weak/upright rear legs into two traits, 89% of observations distributed into two best scores) had greater lifetime reproduction.

Introduction

Over the past 10 years, the average culling frequency of breeding herd females in U.S. commercial swine herds has been 45% and the average sow mortality rate has been 8% (PigCHAMP ™). The primary culling reasons reported for young sows are reproductive failure and leg problems. Therefore, the maintenance of acceptable reproduction rates in young females and the selection of structurally sound replacement females are important factors in increasing sow lifetime reproduction.

The objective of this study was to determine the associations of gilt body composition, growth and structural soundness traits with sow lifetime reproductive performance in commercial females.

Materials and Methods

This study involved 1,447 commercial females from two genetic lines, roughly one-third of the females belonging to a grandparent line and the balance to a parent line. They were progeny of 58 known sires and 835 dams. The evaluation of body composition and structural soundness was carried out on 14 separate dates, and the gilts averaged 124 ± 11 kg body weight and 190 ± 7 d of age at evaluation.

Body composition traits included ultrasonically measured loin muscle area, 10^{th} rib backfat and last rib backfat. Ultrasonic images were taken with a Pie Medical 200 (Classic Medical Supply, Inc., Tequesta, FL) by a single technician who was certified by the National Swine Improvement Federation (Bates and Christian, 1994).

Evaluation of structural soundness included body structure (body length, depth and width, rib shape, top line and hip structure), front leg structure (legs turned, buck knees, pastern posture, foot size and uneven toes), rear leg structure (legs turned, weak/upright legs, pastern posture, foot size and uneven toes) and overall leg action. Evaluation was completed independently by two scorers using a nine-point scale.

Lifetime reproductive traits included lifetime (L), percentage non-productive from total herd days (NPD%), lifetime number born alive (LBA) and number born alive per lifetime days (LBA/L).

Statistical analysis

The heritabilities were estimated with multivariate and the genetic correlations with bivariate animal models using the AI-REML algorithm in the DMU-package (Madsen and

Jensen, 2008). The statistical model for growth and body composition traits included genetic line and evaluation day as fixed effects and animal as a random effect. Prior to analyzing, standard formulas published by NPPC were applied to adjust loin muscle area, 10^{th} rib backfat and the number of days to a constant body weight of 113.5 kg. On the other hand, for last rib backfat, weight at evaluation was used as a linear covariate. Structural soundness traits were analyzed with an identical model to last rib backfat, except scorer was included as an additional fixed effect. Top line, front and rear pastern postures and weak/upright rear legs were each divided into two traits prior to analyses due to intermediate optimum. Turned front and rear legs were expressed as a deviation from the intermediate optimum. The model for lifetime reproductive traits had genetic line and herd entry group as fixed effects and animal as a random effect.

At the termination of data collection, 14% (n = 199) of females were alive. Therefore, preliminary analyses have been implemented using Gibbs sampling procedures allowing incorporation of censored records.

Results

Heritability estimates ranged from 0.50 to 0.70 for growth and body composition traits, from 0.11 to 0.34 for body structure traits, from 0.07 to 0.29 for leg structure and overall leg action and from 0.14 to 0.17 for lifetime reproductive traits. Most of the genetic correlations of growth, body composition and soundness traits with lifetime reproductive traits were low and non-significant ($P > 0.05$; Table 1). However, larger loin muscle area was significantly associated with greater L ($r_g = 0.44$) and increased days to 113.5 kg body weight with greater L and LBA and lower NPD% ($r_g = 0.58$, 0.47 and -0.50, respectively). Body length and rib shape had significant associations with all lifetime reproductive traits. Females with intermediate body length and more shaped ribs had greater L, LBA and LBA/L (r_g = (-0.69, -0.72), (-0.56, -0.63) and (-0.57, -0.56), respectively) and lower NPD% ($r_g = 0.70$ and 0.61, respectively). Wider body was significantly correlated with greater L ($r_g = 0.53$). In general, loin muscle area and body structure traits had a non-significant favorable trend in their genetic correlations with lifetime reproductive traits, while an unfavorable trend was observed in the associations of backfat and days to 113.5 kg body weight with lifetime reproduction. From the leg structure traits, slightly outwards turned front legs were significantly associated with greater LBA and LBA/L (r_g = 0.59 and 0.66, respectively), less upright rear legs with greater LBA/L and lower NPD% ($r_g = -0.55$ and 0.58, respectively) and smaller rear feet with greater L ($r_g = 0.51$). Results also implied that closer to intermediate or at least less upright pastern posture would be associated with improvements in lifetime reproductive traits (r_g = -0.47 - 0.59). The genetic correlations of overall leg action with lifetime reproduction were unfavorable but non-significant (r_g = -0.21 - 0.27).

Discussion

Preliminary results obtained with Gibbs sampling procedures allowing incorporation of censored records were similar to previously discussed estimates, which were obtained by ignoring censoring in DMU. The animals included into the study were preselected for their growth potential and structural soundness by the genetic supplier, which is likely to introduce some bias to these estimates. The genetic correlations obtained in this study indicate that in terms of improving sow lifetime reproductive performance and hence the profitability for pork producers, the most important gilt body composition, growth and structural soundness traits in commercial replacement gilt selection would be closer to intermediate growth rate and body length, more shaped ribs, slightly outwards turned front legs and less upright rear legs. These results need to be interpreted within the distributions of observations present in the dataset. The total range for days to 113.5 kg body weight was 144 - 227 days with 84 % of females reaching the weight by 190 days of age. For body length 89% of observations were divided into scores 4 - 6, 5 describing intermediate length. For rib shape the observations were close to normally distributed over the entire 9-point scale. After transforming records of turned front legs into deviations from optimum, 79% of observations were distributed into two best scores. For upright rear legs 89% of observations were distributed into two best scores after separating weak/upright rear legs into two traits.

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Table 1. Genetic correlations (± s.e.) of body composition, growth and structural soundness traits with lifetime reproductive traits.

	Lifetime reproductive traits			
	L[a]	NPD%[b]	LBA[c]	LBA/L[d]
Body composition / growth				
Adjusted loin muscle area	**0.44 ± 0.17**[e]	-0.16 ± 0.19	0.33 ± 0.17	0.24 ± 0.18
Adjusted 10th rib backfat	0.16 ± 0.20	-0.37 ± 0.19	0.14 ± 0.19	0.14 ± 0.19
Last rib backfat	0.23 ± 0.19	-0.38 ± 0.19	0.18 ± 0.19	0.18 ± 0.19
Adjusted days to 113.5 kg	**0.58 ± 0.17**	**-0.50 ± 0.20**	**0.47 ± 0.18**	0.33 ± 0.20
Body structure				
Body length	**-0.69 ± 0.20**	**0.70 ± 0.21**	**-0.56 ± 0.21**	**-0.57 ± 0.22**
Body depth	-0.28 ± 0.24	0.14 ± 0.25	-0.20 ± 0.23	-0.06 ± 0.24
Body width	**0.53 ± 0.22**	-0.10 ± 0.26	0.34 ± 0.23	0.11 ± 0.25
Rib shape	**-0.72 ± 0.21**	**0.61 ± 0.22**	**-0.63 ± 0.21**	**-0.56 ± 0.23**
High top line[f]	-0.40 ± 0.36	0.31 ± 0.35	-0.12 ± 0.36	0.02 ± 0.35
Weak top line[f]	0.22 ± 0.32	0.00 ± 0.31	0.26 ± 0.30	0.25 ± 0.30
Hip structure	-0.42 ± 0.25	0.32 ± 0.24	-0.29 ± 0.24	-0.18 ± 0.25
Front leg structure				
Front legs turned[g]	0.48 ± 0.27	-0.44 ± 0.28	**0.59 ± 0.24**	**0.66 ± 0.22**
Buck knees	0.13 ± 0.33	-0.10 ± 0.31	0.20 ± 0.31	0.30 ± 0.30
Weak front pasterns[f]	-0.08 ± 0.26	0.23 ± 0.25	-0.05 ± 0.25	-0.11 ± 0.24
Upright front pasterns[f]	-0.47 ± 0.31	0.33 ± 0.33	-0.31 ± 0.32	-0.22 ± 0.33
Front foot size	-0.04 ± 0.30	0.05 ± 0.30	0.01 ± 0.29	-0.12 ± 0.28
Uneven front toes	-0.00 ± 0.32	-0.19 ± 0.31	-0.06 ± 0.31	-0.01 ± 0.31
Rear leg structure				
Rear legs turned[g]	-0.30 ± 0.27	0.16 ± 0.28	-0.16 ± 0.26	0.05 ± 0.27
Weak rear legs[f]	0.19 ± 0.40	-0.34 ± 0.36	0.32 ± 0.36	0.44 ± 0.34
Upright rear legs[f]	-0.38 ± 0.27	**0.58 ± 0.24**	-0.43 ± 0.25	**-0.55 ± 0.23**
Weak rear pasterns[f]	-0.28 ± 0.24	0.11 ± 0.25	-0.14 ± 0.24	-0.02 ± 0.24
Upright rear pasterns[f]	-0.43 ± 0.35	0.59 ± 0.35	-0.38 ± 0.35	-0.47 ± 0.34
Rear foot size	**0.51 ± 0.25**	-0.39 ± 0.29	0.47 ± 0.25	0.37 ± 0.27
Uneven rear toes	-0.13 ± 0.31	-0.30 ± 0.28	-0.20 ± 0.29	0.00 ± 0.29
Overall leg action	0.11 ± 0.33	-0.21 ± 0.31	0.19 ± 0.31	0.27 ± 0.30

[a]Length of lifetime in days from birth to removal or termination of data collection
[b]Non-productive days divided by herd days multiplied by 100%
[c]Lifetime number born alive
[d]Lifetime number born alive divided by length of lifetime
[e]Genetic correlations differing significantly from zero ($P \leq 0.05$) are in bold.
[f]Top line, front and rear pastern postures and weak/upright rear legs were each cut into two traits prior to analyses due to intermediate optimum.
[g]Turned front and rear legs were expressed as deviation from the intermediate optimum.