Genetic Parameters for Feed Intake, Body Condition and Litter Weight in Landrace Sows

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Introduction

One of the goals in pig breeding is to wean large, heavy litters, but these large and heavy litters require a high milk production. High milk production is costly and can result in a poor body condition of sows raising large litters (Grandinson et al. (2005); Valros et al. (2003)). Sows increase their feed intake during lactation to compensate for the negative energy balance caused by milk production, but usually not to a satisfactory level. As a consequence there is a loss of body reserves up to the third week of lactation. (Eissen et al. (2000)). The aim of this paper was to investigate the investments the sow makes raising her litter, with focus on litter weight at three weeks, feed intake three weeks after farrowing and sow body condition at weaning. More specifically we wanted to estimate the heritabilities for, and the genetic correlations between, litter weight, feed intake and body condition.

Material and methods

Data and editing of data. Data for this study was provided by the Norwegian pig breeding company Norsvin and included only Norwegian Landrace sows and their purebred litters. All recordings were made by the farmer or herdsman between January 2008 and September 2009. Weighing of individual piglets was performed within an interval form 17 to 25 days of age, an interval recommended by the breeding company. Weights recorded outside this interval were regarded as missing values in the analyses. Moreover, weight records outside the interval of the uncorrected mean $\pm$ 3 standard deviations (rounded upwards, i.e. 2 − 13 kg) were excluded from the data set. The litter weight was calculated from individual weights of all piglets nursed by the sow. Of the weighed piglets, 3% (from 14% of the litters) were cross fostered. Sow body condition was recorded at weaning. Farmers were instructed by breeding technicians how to do the scoring. The grading was done on a scale from 1-5 (1 = very thin, 2 = thin, 3 = normal, 4 = slightly fat and 5 = fat) with use of half-points in between, resulting in a total of 9 grades for scoring the body condition when registered in the data base (1-9). Feed intake was recorded in feed units (FE) during one day, three weeks after farrowing. Feed intake during that day was in the analyses converted to MJ, where one FE corresponds to 8.8 MJ net energy. Lactation length was limited to an interval between 17 and 49 days. Sows with a lactation length outside the interval were excluded from the data

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set. The studied parities ranged from 1 to 8 and were classified into three categories, 1 for 1st parity sows, 2 for 2nd parity sows and 3 for sows in 3rd parity or older. Herds with less than 30 observations during the time of data collection were excluded from the data set.

After editing, the data set contained information on 3 263 sows and 45 818 piglets from 4 266 litters, with 826 sows having more than one litter. All together 33 herds were represented in the data set. Average lactation length was 35 ± 5.8 days. The number of piglets weighed per litter ranged from 1 to 20. Cross fostered piglets were included in the litter of the foster sow. The pedigree of the animals was traced five generations back when possible and the final pedigree file included 9314 animals. There is a 100% use of artificial insemination and the herds are genetically connected through the use of AI-boars.

 Models and statistical analyses. The traits in focus for this study were litter weight at three weeks, feed intake three weeks after farrowing and sow body condition at weaning. Analysis was done using a multi trait animal model. The following model was used for litter weight:

$$Y_{ijkl} = \mu + h_i + ys_j + p_k + b_1X_{ijkl} + b_2X_{ijklm} + pe_{ijklm} + a_{ijklm} + e_{ijklm}$$

where Y_{ijklm} = litter weight; μ = general mean; h_i = fixed effect of the ith herd; ys_j = fixed effect of the jth year*season at farrowing combination; p_k = fixed effect of the kth parity; b_1X_{ijkl} = regression on number of piglets weighed; b_2X_{ijklm} = regression on age (days) of the piglets at weighing; pe_{ijklm} = random permanent environmental effect; $a_{ijkl\,m}$ = random animal genetic effect; and e_{ijklm} = random residual effect. For feed intake, the regression on age of the piglets at weighing was replaced by a regression on age of the piglets at recording of feed intake. For body condition, the regression on age of the piglets at weighing was replaced by a regression on age of the piglets at weaning. The genetic analysis was performed using the Gibbs sampling method with the program GIBBS1F90. The post-gibbs analysis was made with the program POSTGIBBSF90 (Misztal et al. (2002)). The total number of iterations were 1 000 000. The burn-in period was set to 50 000 iterations after graphical inspection of the plots of the sampled values vs. iterations (Kass et al. (1998)). Every 40th sample was saved and a total of 23 749 samples were included in the post-gibbs analysis. The phenotypic variance was calculated as: $\sigma^2_p = \sigma^2_a + \sigma^2_{pe} + \sigma^2_e$. Descriptive statistics are presented in Table 1.

**Table 1: Descriptive statistics for the traits analyzed**

Trait	N	Mean	S.D.	Min	Max
feed intake, MJ net energy/day	4266	74.2	16.02	4.4	140.8
body condition, score	4266	4.1	1.05	1	9
litter weight, kg	4266	74.5	18.54	5.1	137.4

Results and discussion

The estimated variances obtained from the analysis are presented in Table 2. The marginal posterior distributions of the estimates of heritabilities and genetic correlations are presented in Figure 1.

Table 2: Estimated variances components with S.D as subscript, effective sample size (Ne) and heritabilities (h^2)

Trait	σ^2_a	Ne	σ^2_{pe}	Ne	σ^2_e	Ne	h^2
feed intake	$5.57_{1.84}$	151	$3.85_{2.46}$	36	$130.1_{3.81}$	115	0.04
body condition	$0.12_{0.02}$	122	$0.06_{0.02}$	48	$0.58_{0.02}$	277	0.16
litter weight	$16.25_{2.73}$	619	$4.01_{1.92}$	122	$92.97_{2.89}$	505	0.14
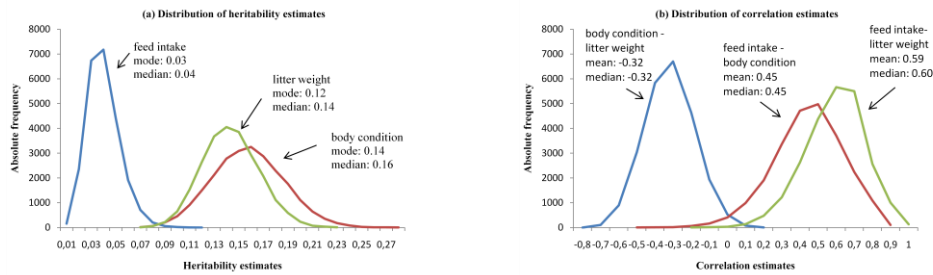
Figure 1: Marginal posterior distributions of the heritability estimates (a) for feed intake, body condition and litter weight, and of the genetic correlations (b) between these traits.

The estimated heritability for feed intake was lower (0.04) than previously found in the literature. Bergsma and colleagues (2008) estimated the heritability for voluntary feed intake during the whole lactation period to 0.30. The low heritability in this study might be explained by the way of recording. Only feed intake of one day in week three after farrowing was used. The heritability estimate of body condition in this study was in between (0.16) the estimates of backfat loss (0.10), using ultrasonic measurement, and weight loss during lactation (0.20) estimated by Grandinson et al. (2005).

The genetic correlation between feed intake and body condition (0.45) was positive and favourable, as well as the correlation between feed intake and litter weight (0.59). Sows with heavy litters are the ones with a high feed intake. Bergsma et al. (2008) estimated a similar but lower genetic correlation between voluntary feed intake during lactation and litter weight gain (0.48). It seems that sows genetically, to a large extent, can meet the needs required for a high milk production when raising heavy litters through a high feed intake. The genetic correlation between litter weight and body condition was negative and unfavourable (-0.32). This is in agreement with Grandinson et al. (2005), who estimated the genetic correlation between loss in body weight during lactation and piglet growth to -0.85 on data from a research herd. Especially primiparous sows are not able to fully compensate for the high energy requirements during lactation (Eissen et al. (2000)). The body resources available for production and reproduction are limited and there is a trade-off between different processes in an animal such as maintenance, own growth, reproduction or growth of offspring (Beilharz et al. (1993)). Thus, there is a conflict concerning nutrient allocation between the

requirements of a sow's current litter versus her own requirements. Indeed, besides resources for milk production, the young sow is still growing (Whittemore (1996)). Increased losses of body reserves will probably result in a higher proportion of sows culled due to reproduction failure (Eissen et al. (2000); Engblom et al. (2007)). A better appetite, resulting in higher feed intake, would decrease the risk of early culling due to low body condition.

Conclusion

Sows with a genetic ability for high feed intake raise heavy litters. Thus, high feed intake throughout lactation is an important sow trait in piglet production. Moreover, the present study shows that a heavy litter is related to a poor body condition of the sow at weaning. Poor body condition can affect reproduction and lead to early culling, whereas a better appetite, resulting in higher feed intake, would decrease that risk. The present study show, that both feed intake and body condition recorded by the herdsman through rather simple methods are heritable. However, further studies on the effect of sow appetite on body condition and reproductive capacity in future parities as well as sow longevity is needed. The results from this study indicate that feed intake or appetite and body condition may be considered to be included in the genetic evaluation.

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