## MATERNAL AND INDIVIDUAL GENETIC EFFECTS ON PIGLET WEIGHT

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### SUMMARY

Genetic parameters for piglet weight were estimated using DFREML procedure in two strains of Iberian pigs and in records proceeding from a 4 x 4 diallelic design between ancient strains. The model of analysis included four random effects: direct and maternal genetic effects, common environmental effect and residual, and as fixed effects the sex, the farrowing period and the parity of the dam. Inbreeding coefficients of dam and piglet and the parameters of the Eisen et al. (1983) model were also included as covariables in the analysis of strains and of the diallel cross, respectively.

### INTRODUCTION

Prolificacy has been the reproductive trait traditionally most studied in pig populations. There are other reproductive traits whose genetic basis is not well known. It is recognised that differences in milk production capacity exist within and between pig breeds and crosses. One practical measure of milk production in sows is the litter weight when the only feed of the piglets is the milk intake. The individual piglet weight is not usually recorded with the common farm management. However, the analysis of the preweaning growth, using animal models with maternal effects, widely used in cattle and sheep data, allows a complementary knowdledge of the genetics of maternal ability of sows.

### MATERIALS AND METHODS

The available data for the present study were collected from several lines of Iberian breed housed in an experimental farm (Dehesón del Encinar, Toledo, Spain). The first data set proceeds from four ancient strains of diverse morphology and geographical origin: 1) *Ervideira*, 2) *Campanario*, 3) *Caldeira* and 4) *Puebla*, crossed from 1947 to 1957 in a complete 4 x 4 diallel design with 16 progeny genetic types. The other two data sets were collected from 1963 to 1993. The second one in a synthetic line (*Torbiscal*) issued from the four quoted strains and the third one in the *Guadyerbas* strain, that proceeds from the ancient *Puebla*.

Table 1. Description of data used in the analysis of piglet weight at 21 days

| Data set | Diallelic cross | *Torbiscal* | *Guadyerbas* |
|---|---|---|---|
| Animals with records | 15536 | 27473 | 6930 |
| Dams | 796 | 1385 | 387 |
| Litters | 2657 | 4323 | 1222 |
| Farrowing periods | 33 | 92 | 90 |
| Mean (kg) | 4.04 | 4.58 | 4.46 |
| Coefficient of variation (%) | 24.94 | 20.66 | 20.86 |

There were two farrowing periods per year up to 1973 and since then four annual farrowing periods. Weaning is accomplished at 6-7 weeks, but creep feed is supplied to the piglets from 21 days of age. Piglet weight at 21 days is routinely recorded in all the animals born in the herd but records from crossfostered piglets have been excluded of the analysed data. Full genealogy of all the animals is available. A description of the diverse files is summarized in Table 1.

Variance components and fixed effect were estimated using DFREML (Meyer, 1991). An individual animal model with maternal effects was used to analyse the piglet weight:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Za} + \mathbf{Z_M a_M} + \mathbf{Wc} + \mathbf{e}$$
$$\mathbf{E(y)} = \mathbf{X}\boldsymbol{\beta}$$
$$\mathbf{var(y)} = \mathbf{ZAZ'}\sigma_A^2 + \mathbf{Z_M AZ'_M}\,\sigma_M^2 + \mathbf{WW'}\sigma_c^2 + \mathbf{I}\sigma_e^2$$

where **y** is a vector of observations of the trait; **X**, **Z** and $\mathbf{Z_M}$ are the known incidence matrix; a is a vector of additive genetic effects; **W** and **c** are respectively the incidence matrix and the vector of common environmental effects; $\mathbf{a_M}$ is a vector of maternal additive genetic effects, assumed to be uncorrelated with **a**, and **e** is a vector of residuals. Previous analysis evidenced that genetic covariance between direct and maternal effects on piglet weight at 3 weeks is not relevant in Iberian pigs (Rodriguez et al., 1994).

$\boldsymbol{\beta}$ is a vector of fixed effects that includes in all cases: farrowing period, piglet sex (male or female) and parity of the dam (1, 2, 3, 4, 5 and ≥ 6). Different covariables were also included in $\boldsymbol{\beta}$ for the analysis of the data sets.

In the strains *Torbiscal* and *Guadyerbas*, dam ($F_d$) and piglet ($F_p$) inbreeding coefficients were considered as covariables in order to estimate the inbreeding depression of the trait.

The analysis of the diallelic cross data was focused to the estimation of crossbreeding parameters according to the procedure suggested by Komender and Hoeschele (1989) to obtain direct estimates and in this case $\boldsymbol{\beta}$ included parameters of the model by Eisen et al. (1983): $l_i$ = direct effect of line $i$; $m_i$ = maternal effect of line $i$; $h$ = mean heterosis effect; $h_i$ = mean line heterosis effect of line $i$; $s_{ii'}$ = specific heterosis effect of crossing lines $i$ and $i'$; $r_{ii'}$ = specific reciprocal effect of crossing lines $i$ and $i'$. The following restrictions were imposed:

$$\textstyle\sum_i l_i = \sum_i m_i = \sum_i h_i = \sum_i r_{ii'} = \sum_{i'} r_{ii'} = \sum_i s_{ii'} = \sum_{i'} s_{ii'} = 0$$
$$s_{ii'} = s_{i'i} \qquad r_{ii'} = -r_{i'i} \quad (i = 1,4;\ i' = 1,4)$$

In all the DFREML analysis, the iterations stopped when the variance of the likelihood funtion values was less than $10^{-8}$.

## RESULTS

The estimates of variance components obtained in the three analysed files are presented in Table 2. The contribution of the piglet additive genotype to the variance of the weigth at 21 days is low. The 95% confidence intervals for heritabilities were: 0 to 0.023 (diallel cross), 0.001 to 0.033 (*Torbiscal*) and 0.004 to 0.162 (*Guadyerbas*). Maternal heritability shows greater values, being the respective confidence intervals: 0.144 to 0.208, 0.136 to 0.186 and 0.094 to 0.222. The proportion of the variance assignable to the common environmental effect presents similar values with confidence intervals: 0.153 to 0.192, 0.118 to 0.146 and 0.134 to 0.202.

The estimated differences for weight at 21 days between male and female piglets were very similar in the three populations: -0.214 ± 0.013, -0.210 ± 0.010 and -0.235 ± 0.019 kg for the diallel cross, *Torbiscal* and *Guadyerbas* respectively.

Table 2. Estimates of variance components for piglet weight. SE between brackets

| Data set | Diallelic cross | *Torbiscal* | *Guadyerbas* |
|---|---|---|---|
| $\sigma_A^2$, direct additive variance | 0.7 x $10^{-6}$ | 0.015 | 0.073 |
| $\sigma_M^2$, maternal additive variance | 0.144 | 0.133 | 0.138 |
| $\sigma_c^2$, common environmental variance | 0.142 | 0.114 | 0.146 |
| $\sigma_e^2$, residual variance | 0.539 | 0.595 | 0.516 |
| $h_A^2 = \sigma_A^2/\sigma_P^2$ | 0.00 (0.01) | 0.02 (0.01) | 0.08 (0.04) |
| $h_M^2 = \sigma_M^2/\sigma_P^2$ | 0.17 (0.02) | 0.16 (0.01) | 0.16 (0.03) |
| $c^2 = \sigma_c^2/\sigma_P^2$ | 0.17 (0.01) | 0.13 (0.01) | 0.17 (0.02) |

The effect of the parity of the sow is presented in Table 3. The last class includes records from the sixth and later parities up to the $15^{th}$. The results evidenced a possitive effect of birth order on piglet weight until the third parity, in the data recorded on the diallelic cross and *Guadyerbas*. Howewer in *Torbiscal* data the heaviest piglets are those born in the second parity, and thereafter a negative effects of parity on piglet weight is observed.

Table 3. Estimates of mean differences between parities for piglet weight. SE between brackets

| Parity | Diallelic cross | *Torbiscal* | *Guadyerbas* |
|---|---|---|---|
| 2 - 1 | 0.354 (0.030) | 0.072 (0.023) | 0.376 (0.047) |
| 3 - 1 | 0.366 (0.034) | -0.013 (0.026) | 0.285 (0.052) |
| 4 - 1 | 0.256 (0.038) | -0.070 (0.029) | 0.263 (0.060) |
| 5 - 1 | 0.227 (0.045) | -0.150 (0.033) | 0.150 (0.068) |
| 6 - 1 | 0.020 (0.044) | -0.290 (0.030) | 0.140 (0.064) |

The regression coefficients of piglet weight on $F_d$ and $F_p$ allow an estimation of the value of inbreeding depression for this trait. The effects on the trait of increases of a 10% of dam and piglet inbreeding are shown in Table 4. In *Torbiscal*, the mean values of dam and piglet inbreeding coefficients were 0.045 and 0.040, with ranges of variation from 0 to 0.366 ($F_d$) and from 0.007 to 0.424 ($F_p$). The corresponding mean values in *Guadyerbas* were 0.064 and 0.063, with respective ranges from 0.067 to 0.449 and from 0.110 to 0.520.

Table 4. Effect of inbreeding on piglet weight

| Strain | *Torbiscal* | | *Guadyerbas* | |
|---|---|---|---|---|
| Effect of 10% inbreeding of | dam | piglet | dam | piglet |
| Estimate | -0.056 | -0.097 | -0.162 | -0.086 |
| SE | 0.032 | 0.026 | 0.054 | 0.046 |

The results of the diallel cross analysis related to the parameters of the model by Eisen et al. (1983) are summarized in Table 5, that only includes the estimates significantly different from zero. The two most remarkable aspects are the differences between lines in maternal effects and the existence of significant mean heterosis for the trait. Other line and specific heterosis effects have also been evidenced.

Table 5. Estimates of significant crossbreeding parameters (Eisen et al., 1983) for piglet weight

| | $l_2$ | $l_3$ | $m_3$ | $m_4$ | $h$ | $h_2$ | $h_3$ | $s_{24}$ | $s_{34}$ |
|---|---|---|---|---|---|---|---|---|---|
| Estimate | -0.153 | 0.117 | -0.204 | 0.299 | 0.093 | 0.059 | -0.057 | -0.068 | 0.076 |
| SE | 0.045 | 0.045 | 0.093 | 0.078 | 0.029 | 0.029 | 0.029 | 0.026 | 0.026 |

## DISCUSSION

According to the present results, the maternal additive effect is the most important component of the variation of the piglet weight at 21 days, when the milk of the dam has been the only available feed for the piglets. When feed is supplied the influence of the additive piglet genotype on growth increases. Béjar et al. (1993) using un animal model without maternal effects found, in *Torbiscal* strain, the following parameters for piglet weight at 50 days: $h_A^2$ =0.10 and $c^2$ = 0.27.

Following Walker and Young (1992), milk yield in gilts is around a 20% lower than multiparous sows. The possitive effect of birth order on litter size and litter weight has been evidenced in Iberian pigs (Pérez-Enciso and Gianola, 1992; Rodriguez el al., 1994). There is an increase of litter size until the fifth parity. Piglet growth in large litters is restricted by milk production of sows. In the present analysis of data from diallel cross and *Guadyerbas* the heaviest piglets are those born in the second or the third parity. Litter size in *Torbiscal* is about 1.2 piglets greater that in the other populations, and the heaviest piglets in this strain are those born in the second parity and, thereafter, a strong negative effect of the parity on piglet weight is observed.

Our results evidence a consistent negative effect of dam and piglet inbreeding on piglet weight in the two analyzed populations. Expressed as percentage of the means, the depression is 1.22 and 3.63 for a 10% of inbreeding of the dam, in *Torbiscal* and *Guadyerbas* strains respectively. The effect of dam inbreeding indicates a possible depression on milk ability of sows. The effect of piglet inbreeding with the heterosis effects found in the analysis of data from diallelic cross suggest the influence of non-additive effects of the piglet genotype on the weight at 3 weeks.

The differences in maternal effects between lines indicate differences in milk production among ancient strains of Iberian pigs of similar litter size (Pérez-Enciso and Gianola, 1992).

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