Animal breeding scheme applied to the quality of pure Iberian montanera pigs

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SUMMARY

Selection programs are not frequent in the extensive Iberian porcine sector. The traditional company of Iberian pig products located in Jabugo (Sierra de Huelva), Sánchez Romero Carvajal (SRC), with the collaboration and assessment of the Animal Breeding Department of INIA, is making since the year 2012 an unusual effort to develop and implement a breeding selection scheme focused on the Iberian purebred products labelled as Bellota. The animals involved in this program belong to one herd which is placed in two different farms, Montecastilla and Tejarejo (La Granada de Riotinto). 1,205 animals of known pedigree were controlled for selection of growth, body composition, meat and fat quality traits. The main registered traits were average daily gain in montanera, slaughter and carcass weight and weight of premium cuts (ham, shoulders and loins). Besides, backfat fatty acid profile and quality traits as intramuscular fat percentage, color, thawing and cooking water loss and shear force were measured in loin as quality traits. Breeding values for these traits were estimated using an Animal model. Genetic predictions for maternal traits (number of piglets born alive and litter weight at weaning) were performed also using Animal models. Data from 5,134 litters born in 88 batches of 1,456 dams and 22 sires were used. This information allowed estimating heritability and genetic correlation as well as to build a combined index for each trait weighting the breeding values by their corresponding economic values. In addition to this, molecular genetic studies on some of the traits cited above are also being implemented. These studies will allow increasing the efficiency of the conventional selection program in the future.

INTRODUCTION

Selection programs are not frequent in Iberian pig populations despite most of the commercial porcine breeds have implemented these programs for several decades. For instance, Duroc breed, used as paternal line in cross with Iberian pigs, has been subjected to...
strong breeding programs for growth and lean percentage of carcass and established lines specialized for intramuscular fat percentage (ANPS, 2011). The main objective of the production of Iberian pigs is to obtain heavy pigs destined to be processed as high quality fresh and dry-cured meat products (Silió 2000, p. 511-520). According with the Spanish law, there are three different systems of fattening: 1) Bellota: extensive system in which the animals are fattened mainly with acorns and grass from November to late February, named montanera period, b) Cebo de campo: open-air system in which the animals are fattened with feed and occasionally they take advantage of the natural resources different from acorns and c) Cebo: intensive system in which the animals are fattened with commercial feed. (BOE, 2014). Sánchez Romero Carvajal (SRC) is a traditional enterprise of Iberian pig products located in Sierra de Huelva. SRC with the collaboration and assessment of the Pig Breeding and Genetics Group of INIA are implementing and developing a breeding selection scheme focused in Iberian purebred pigs fattened in montanera. As a first step, a large number of data of different productive, reproductive and meat quality traits are being collected. The final breeding goal of the program consists in combining this information to develop dam and sire lines to obtain purebred Iberian pigs with high premium cuts yield, and high meat and fat quality.

MATERIAL AND METHODS

DATA COLLECTION

Data from 5,134 litters born in 88 farrowing batches of 1,456 dams and 22 sires were recorded. Sows were allocated on traditional farrowing houses. The traits recorded from these data were the number of piglets born alive (NBA) and litter weight at weaning (LWW). For productive and meat quality traits, data from 1,205 montanera pigs slaughtered in 15 batches, coming from 553 dams and 17 sires were used. The main traits recorded were: average daily gain during montanera fattening period (ADG), carcass weight and percentage of premium cuts (ham, shoulders and loins) on carcass, and loin intramuscular fat content (%IMF), Minolta color, shear force, compression test and thawing and cooking water losses, measured in loin samples, and backfat composition of the main 12 fatty acids.

GENETIC EVALUATION

Animal models were used to estimate heritability, genetic correlations and breeding values. For reproductive traits the following bivariate model was used:

\[
\begin{pmatrix}
\mathbf{y}_1 \\
\mathbf{y}_2
\end{pmatrix}
= \begin{pmatrix}
X_1 & 0 & 0 \\
0 & X_2 & 0
\end{pmatrix}
\begin{pmatrix}
\mathbf{b}_1 \\
\mathbf{b}_2
\end{pmatrix}
+ \begin{pmatrix}
Z_1 & 0 & 0 \\
0 & Z_2 & 0
\end{pmatrix}
\begin{pmatrix}
\mathbf{u}_1 \\
\mathbf{u}_2
\end{pmatrix}
+ \begin{pmatrix}
\mathbf{e}_1 \\
\mathbf{e}_2
\end{pmatrix}
\]

where \(y_1\) and \(y_2\) are the records for NBA and LWW, respectively, the vectors \(u_1\) and \(u_2\) are random additive genetic effects, \(p_1\) and \(p_2\) are the permanent environmental effects of each sow, \(b_1\) and \(b_2\) the farrowing batch effects and \(e1\) and \(e2\) the environmental random effects'. The incidence matrices \(X_1\) and \(X_2\) associate \(y_1\) and \(y_2\) with elements of \(b_1\) and \(b_2\), \(Z_1\) and \(Z_2\) with \(u_1\) and \(u_2\), \(W_1\) and \(W_2\) with \(p_1\) and \(p_2\) and \(B_1\) and \(B_2\) with \(b_1\) and \(b_2\). Farrowing batch was considered as random effect since included 88 levels.

For productive traits the following multitrait model was used:

\[
\begin{pmatrix}
\mathbf{y}_1 \\
\mathbf{y}_2 \\
\mathbf{y}_3 \\
\mathbf{y}_4 \\
\mathbf{y}_5
\end{pmatrix} = \begin{pmatrix}
X_1 & 0 & 0 & 0 & 0 \\
0 & X_2 & 0 & 0 & 0 \\
0 & 0 & X_3 & 0 & 0 \\
0 & 0 & 0 & X_4 & 0 \\
0 & 0 & 0 & 0 & X_5
\end{pmatrix} \begin{pmatrix}
\mathbf{b}_1 \\
\mathbf{b}_2 \\
\mathbf{b}_3 \\
\mathbf{b}_4 \\
\mathbf{b}_5
\end{pmatrix} + \begin{pmatrix}
Z_1 & 0 & 0 & 0 & 0 \\
0 & Z_2 & 0 & 0 & 0 \\
0 & 0 & Z_3 & 0 & 0 \\
0 & 0 & 0 & Z_4 & 0 \\
0 & 0 & 0 & 0 & Z_5
\end{pmatrix} \begin{pmatrix}
\mathbf{u}_1 \\
\mathbf{u}_2 \\
\mathbf{u}_3 \\
\mathbf{u}_4 \\
\mathbf{u}_5
\end{pmatrix} + \begin{pmatrix}
\mathbf{e}_1 \\
\mathbf{e}_2 \\
\mathbf{e}_3 \\
\mathbf{e}_4 \\
\mathbf{e}_5
\end{pmatrix}
\]

where \(y_i\) and to \(y_5\) are the records for ADG, the percentage of ham, shoulders and loins and the percentage of intramuscular fat, respectively. The vectors of fixed effect \(\mathbf{b}_i\) included the farrowing batch (17 levels) for ADG and the slaughter batch (15) and carcass weight as a covariate for the % of hams, shoulders, loins and IMF. The vectors \(u_i\) and \(u_5\) are random additive genetic effects and \(e_i\) and \(e_5\) the environmental effects. The incidence matrices \(X_i\) to \(X_5\) associate \(y_i\) to \(y_5\) with elements of \(b_i\) and \(b_5\) and \(Z_i\) to \(Z_5\) with \(u_i\) and \(u_5\).

Lastly, an analogous multitrait model which included a litter random effect \(c\) was used to estimate heritability and genetic correlations between % IMF, thawing and cooking losses and shear force. To perform these analyses PEST (Groenveld, 1990) and VCE 5 (Kovac & Groenfeld, 2003) software was used.

RESULTS

Table I shows the results for reproductive traits. Heritability values were low for both traits but similar to those reported for other breeds. Table II shows the results for productive traits; heritability was low for ADG while for the other traits showed moderate values. There were a positive genetic correlation between body composition traits (% of hams, shoulders and loins) and a negative genetic correlation between body composition traits and IMF. Lastly, Table III shows the genetic parameters for meat quality traits. Heritability estimates were moderate for all the traits; in addition to this, IMF was negatively correlated with all the traits and there were high and positive correlations between thawing loss, cooking loss and shear force.

DISCUSSION

According to the results obtained, breeding programs can be implemented in this Iberian purebred population for the traits studied. The genetic correlations observed between body composition traits and IMF point out that selection for body composition

<table>
<thead>
<tr>
<th>Trait</th>
<th>NBA</th>
<th>LWW</th>
</tr>
</thead>
<tbody>
<tr>
<td>p²</td>
<td>0.06 (0.02)</td>
<td>0.12 (0.19)</td>
</tr>
<tr>
<td>LWW</td>
<td>0.14 (0.03)</td>
<td></td>
</tr>
<tr>
<td>p²</td>
<td>0.05 (0.02)</td>
<td>0.19 (0.03)</td>
</tr>
</tbody>
</table>

traits could decrease the percentage of IMF, leading to a decrease of meat quality. Therefore, a balance between these breeding values should be taken into account in the selection of breeding animals (García-Casco et al. 2014, p. 388-395). In addition to this, breeding values estimation allows to build combined index for each trait weighting the genetic values by their corresponding economic values. Over the last four years, SRC is following these parameters to carry out selection of the breeding animals. IMF was also included in the third model since is the most important trait related with meat quality. It should be noted that the different heritability values of IMF estimated in the two multitrait models are due to the multitrait model used to estimate the genetic components of IMF, thawing loss, cooking loss and shear force includes litter random effects and less phenotypical registers than the one used to estimate genetic parameters of ADG, % of premium cuts and IMF.

It is worth to note the valuable effort made by both SRC and Pig Breeding and Genetics Group to get the animal information, genetic control of the animals, the data recording from pigs fattened in montanera and from individual carcasses, individual fat and meat samples in slaughterhouse and the meat and fat quality lab data. Finally, molecular genetic studies on some of the traits cited above are also being implemented. These studies will allow increasing the efficiency of the conventional selection program in the future.

**BIBLIOGRAPHY**


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### Table II. Heritability estimates (diagonal) and genetic correlation between ADG, % of hams, shoulders and loins and IMF (above diagonal) and standard errors (between brackets)

<table>
<thead>
<tr>
<th>Trait</th>
<th>ADG</th>
<th>Hams, %</th>
<th>Shoulders, %</th>
<th>Loins, %</th>
<th>IMF, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG</td>
<td>0.09 (0.04)</td>
<td>-0.04 (0.08)</td>
<td>-0.23 (0.12)</td>
<td>-0.01 (0.07)</td>
<td>0.34 (0.07)</td>
</tr>
<tr>
<td>Hams, %</td>
<td>-</td>
<td>0.28 (0.04)</td>
<td>0.75 (0.10)</td>
<td>0.84 (0.06)</td>
<td>-0.31 (0.08)</td>
</tr>
<tr>
<td>Shoulders, %</td>
<td>-</td>
<td>-</td>
<td>0.10 (0.03)</td>
<td>0.81 (0.09)</td>
<td>-0.10 (0.10)</td>
</tr>
<tr>
<td>Loins, %</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.39 (0.06)</td>
<td>-0.40 (0.17)</td>
</tr>
<tr>
<td>IMF, %</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.27 (0.04)</td>
</tr>
</tbody>
</table>

### Table III. Heritability estimates (diagonal) and genetic correlation between IMF, thaw loss, cooked loss and shear force (above diagonal) and standard errors (between brackets)

<table>
<thead>
<tr>
<th>Trait</th>
<th>IMF, %</th>
<th>Thaw loss, %</th>
<th>Cooked loss, %</th>
<th>Shear force, kg</th>
<th>$c^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMF, %</td>
<td>0.36 (0.13)</td>
<td>-0.84 (0.13)</td>
<td>-0.47 (0.25)</td>
<td>-0.68 (0.17)</td>
<td>0.11 (0.06)</td>
</tr>
<tr>
<td>Thaw loss, %</td>
<td>-</td>
<td>0.20 (0.07)</td>
<td>0.87 (0.07)</td>
<td>0.87 (0.19)</td>
<td>0.17 (0.07)</td>
</tr>
<tr>
<td>Cooked loss, %</td>
<td>-</td>
<td>-</td>
<td>0.33 (0.09)</td>
<td>0.85 (0.16)</td>
<td>0.10 (0.05)</td>
</tr>
<tr>
<td>Shear force, %</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.39 (0.12)</td>
<td>0.06 (0.06)</td>
</tr>
</tbody>
</table>

$c^2$: litter random effects