LocalPork – breeding for local conditions

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Summary

The LocalPork project aims to improve the efficiency of pork production in Brazil. Pigs in Brazil are usually fed a diet based on corn and soybean. Growing these pigs on a diet that includes local alternative ingredients raises a number of questions related to breeding for such an environment. First, what is the economic and environmental impact of alternative local diets. Second, what are the purebred-crossbred genetic correlations and the extent of genotype by environment interaction. Third, how to accurately predict breeding values based on crossbred performance. Performance of pigs in Brazil that are fed a reference or alternative diets was predicted and alternative diets that include Macaúba or other co-products were found to improve the economic and environmental performance of pork production. Genotype by feed interaction was investigated in crossbred pigs that were fed either a corn and soybean based diet or a diet based on wheat, barley and co-products. Genetic correlations between the diets for growth and residual feed intake were found to be high. The genetic correlation between purebreds and crossbreds for residual feed intake was however found to be only moderate, 0.62. Taking into account the breed origin of haplotypes in crossbreds when predicting breeding values did not substantially increase their accuracies. We speculate that the moderate value of the purebred-crossbred genetic correlation is mainly due to GxE caused by differences in environmental factors, other than diet.

Keywords: local diets, environment, GxE, feed efficiency, purebred-crossbred correlation

Introduction

To increase the availability of low cost, locally produced pork, the LocalPork project aims to improve the efficiency of pig growth in Brazil. Rising prices of corn, soybean and transportation increase the need to feed local co-products. Use of co-products from food and energy production (Zijlstra and Beltranena, 2013) and ingredients from local non-arable land such as pasture that is not suitable for crop production) can be a viable alternative. New ingredients may impact on performance, due to e.g. digestibility of nutrients or energy content.

Breeding programs for pigs increasingly emphasize the efficiency of production. Breeding programs are also becoming more globally organized. When the aim is to produce pork by efficiently growing crossbred pigs that are fed local diets a number of questions arise that relate to breeding for such an environment. First we want to know the economic and
environmental impact of feeding alternative local diets. Second, we would like to know the purebred-crossbred genetic correlations and the extent of genotype by environment interaction (GxE) in the form of genotype by feed, and genotype by climate interaction. Third, we want to predict accurate breeding values of purebreds for the performance of crossbreds in local conditions. These three aspects; 1) the impact of feeding local diets, 2) the levels of GxE, and 3) the prediction of crossbred performance are investigated in the LocalPork project.

In these analyses, a global breeding program was assumed, executed in western Europe (WE), and a target production environment was assumed in Minas Gerais state in Brazil (MG) which has 12% of Brazil’s 40 million pigs (2015). An important difference between WE and MG are the predominant diets for pigs. The western European diet is based on wheat, barley and co-products (WB), and the Brazilian diet is based on corn and soybean (CS). For Brazil alternative diets were assumed with co-products such as wheat middlings and citrus pulp, and also a diet based on macaúba kernel cake. Macaúba kernel cake is an emerging co-product in Brazil that is obtained after extracting oil from the fruits of the macaúba palm and has nutritional values suitable for inclusion in pig diets (Costa Junior et al., 2015).

**Economic and environmental impact of alternative diets**

The performance of pigs on a Brazilian reference diet, containing mainly corn and soybean, and on two alternative diets was predicted by Ali et al. (2017). The alternative diets were a macaúba based diet, including 20% macaúba kernel cake and a co-products diet including 10% macaúba kernel cake and a total of 24% of wheat middlings, citrus pulp and sugarcane molasses (refer to Ali et al. (2017) for complete diet compositions). Inclusion of co-products in the diets had a positive economic and environmental impact (Table 1). Especially land use (and greenhouse gases emission associated with land use change) were reduced but also the economic performance of diets improved with the inclusion of alternative ingredients. Energy requirements for the co-products diet were higher, mainly due to the inclusion of citrus pulp which requires drying. Using local co-products, such as macaúba, can have positive economic and environmental impact and may therefore lead to local production systems that are different from the circumstances of selection candidates in global breeding programs.

*Table 1. Costs and environmental impacts of pig production on different diets*.  

<table>
<thead>
<tr>
<th>Costs per pig&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed cost (USD)</td>
<td>Reference&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>GHG&lt;sup&gt;f&lt;/sup&gt; (kg CO₂-eq)</td>
<td>67.3</td>
</tr>
<tr>
<td>Land use (m²)</td>
<td>567.8</td>
</tr>
<tr>
<td>Energy (MJ)</td>
<td>1512</td>
</tr>
</tbody>
</table>

<sup>a</sup> results from (Ali et al., 2017)  
<sup>b</sup> finished pig with 104 kg live weight at slaughter, <sup>c</sup> reference diet scenario, <sup>d</sup> macaúba kernel cake based scenario, <sup>e</sup> co-products based scenario, <sup>f</sup> greenhouse gases emission including emission from land use change

**Genotype by feed interaction**

When breeding for local production (MG) with a global breeding program (WE), GxE is expected to be considerable. Feed efficiency is a priority trait in pig breeding programs and has been reported to be more sensitive to environmental differences than other production
traits (Knap and Wang, 2012). The GxE between MG and WE may be due to diet, temperature, humidity, housing, and many other differences between the two locations. To test parameters separately is not easy, and maybe also not needed if they cannot be controlled such as climatic conditions. The effects of diet can however be tested.

The WB diet and the CS diet were tested on in total 2,230 three-way crossbred pigs at Schothorst Feed Research B.V. (Lelystad, the Netherlands). Genetic correlations for phenotypes on the different diets were close to one for average daily gain and average daily feed intake, high for residual feed intake and moderate for backfat thickness (Table 2).

<table>
<thead>
<tr>
<th></th>
<th>ADG^a</th>
<th>FI^b</th>
<th>BF^c</th>
<th>RFI^d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CS^e</td>
<td>WB^f</td>
<td>CS^e</td>
<td>WB^f</td>
</tr>
<tr>
<td>h^2</td>
<td>0.34</td>
<td>0.22</td>
<td>0.42</td>
<td>0.19</td>
</tr>
<tr>
<td>(s.e.)</td>
<td>0.11</td>
<td>0.11</td>
<td>0.12</td>
<td>0.11</td>
</tr>
<tr>
<td>r_g</td>
<td>0.99</td>
<td>0.97</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>(s.e.)</td>
<td>0.22</td>
<td></td>
<td>0.23</td>
<td></td>
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</tbody>
</table>

^a ADG = average daily gain, ^b FI = average daily feed intake, ^c BF = backfat thickness, ^d RFI = residual feed intake, ^e CS = corn and soybean based diet, ^f WB = wheat, barley, co-products based diet.

Heritabilities were higher on the CS diet except for RFI. The moderate to high genetic correlations indicate that die may not contribute much GxE. Heritabilities of performance on alternative local diets, such as those in Ali et al. (2017), and correlations with performance on current diets are not yet available.

Prediction of crossbred performance

Growing pigs are typically crossbreds. The success of selection in purebreds, or the need to collect phenotypes in crossbreds, depends on the purebred-crossbred genetic correlation. Also, the effect of a SNP allele in a crossbred may depend on the breed that contributed the allele.

The genetic correlation between purebred and crossbred performance was estimated to be 0.62 for residual feed intake based on individual feed intake records on 22,984 purebred and 8,657 crossbred pigs. This purebred-crossbred genetic correlation is smaller than the genetic correlation for residual feed intake on CS versus WB diets (Table 2) indicating that besides diet, other factors cause GxE between purebred and crossbred performance.

A method (BOA) was developed that assigns the breed origin of haplotypes in crossbreds for up to 94.6% of haplotypes in real data (Sevillano et al., 2016), and correctly assigned breed origin for >90% of haplotypes in simulated data (Vandenplas et al., 2016). When BOA was applied to estimate breeding values of animals in a sire line (Synthetic) and animals in a dam line (Landrace) based on 1,706 genotyped crossbred offspring the accuracies were higher with BOA in the Landrace but not in the Synthetic line (Table 3).

Conclusions

The use of co-products in pig diets in Brazil was found to reduce feed cost and to reduce environmental impacts of land use and land use change. Increased pressure on prices of corn and soybean, as well as efforts to reduce environmental impact of pig and feed production could therefore move pork production towards alternative diets that include local co-products.
Given the only moderate genetic correlation between purebred and crossbred performance for residual feed intake, selection for efficient growth of crossbreds may need to take into account performance of crossbred pigs. The high genetic correlation for residual feed intake between the CS and WB diets suggests that differences between diets may play a minor role in GxE.

Additional accuracy from estimating breeding values based on breed origin of alleles in crossbreds was limited. This leads us to speculate that the moderate value of the purebred-crossbred genetic correlation is due to GxE caused by differences in environmental factors, other than diet, between purebreds and crossbreds.

Table 3. Accuracies$^a$ of breeding values estimated with BOA$^b$, G$_A^c$, G$_H^d$ models.

<table>
<thead>
<tr>
<th></th>
<th>Synthetic boar line</th>
<th>Landrace dam line</th>
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<tbody>
<tr>
<td></td>
<td>BOA$^b$</td>
<td>G$_A^c$</td>
</tr>
<tr>
<td>ADG$^e$</td>
<td>0.104</td>
<td>0.102</td>
</tr>
<tr>
<td>BF$^f$</td>
<td>0.178</td>
<td>0.199</td>
</tr>
<tr>
<td>LD$^g$</td>
<td>0.158</td>
<td>0.179</td>
</tr>
</tbody>
</table>

$^a$ results from (Sevillano et al., 2017)

$^b$BOA, model with breed-specific relationship matrices, $^c$G$_A$, model with G matrix based on across breed allele frequencies, $^d$G$_H$, model with G matrix based on breed-specific allele frequencies.

$^e$ADG = average daily gain, $^f$BF = backfat thickness, $^g$LD = loin depth.

Acknowledgements

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List of References


