Evaluating the potential of breeding protein efficient pigs: preliminary estimates of heritability in a Swiss Large White pig population

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Introduction

Pig production contributes importantly to environmental pollution through the emission of nitrogen waste. Since many countries do not meet the plant-protein demand of livestock with current feed cultivation practices, an important part of high-quality protein feed, most importantly soybean meal, is imported from South America. Consequently, the high global demand for protein results in an increased competition of agricultural land for human food and animal feed, ultimately leading to the large-scale loss of ecological habitats. It is therefore desirable to improve protein efficiency, i.e. the proportion of dietary protein that is fixed in the body, of pigs, an important livestock species, through selective breeding. However, little knowledge is available about the inheritance pattern and genetic architecture of protein efficiency. Similarly, the genes underlying protein efficiency and their functions, essential for assessing the potential to breed pigs with higher protein efficiency, has not yet been assessed.

Materials and Methods

We used data of 294 offspring of 17 sires and 56 dams from previous experiments (Ruiz-Ascacibar et al., 2017). Nitrogen efficiency, as a proxy for protein efficiency, of the empty body (*NEffEB*) and of the carcass (*NEffCarc*) were calculated as the proportion of fixed protein in the entire body and the carcass, respectively, from the total dietary protein intake. We estimated the genetic (h^2) and environmental variance components (CE^2) of *NEffEB* and *NEffCarc* using a mixed-effect Gaussian animal model (Henderson, 1984) following a Bayesian framework (Hadfield, 2010). We assessed phenotypic correlations of *NEffEB* with phosphorus efficiency, water, raw ash and fat content of the empty body of a subset (N=73) for which this information was available. The correlation of *NEffEB* with the number of days slaughtering was delayed because a pig did not reach the target body weight was calculated for the entire dataset.

Results

The heritability of N efficiency of the empty body was higher than the one of the carcass ($h^2_{NEffEB} = 0.32\ [0.15, 0.59]$ and $h^2_{NEffCarc} = 0.16\ [0.08, 0.41]$) (Fig. 1). The common environment also contributed to the phenotypic variation in *NEffEB* ($CE^2 = 0.13\ [0.08, 0.27]$) and *NEffCarc* ($CE^2 = 0.16\ [0.09, 0.25]$).

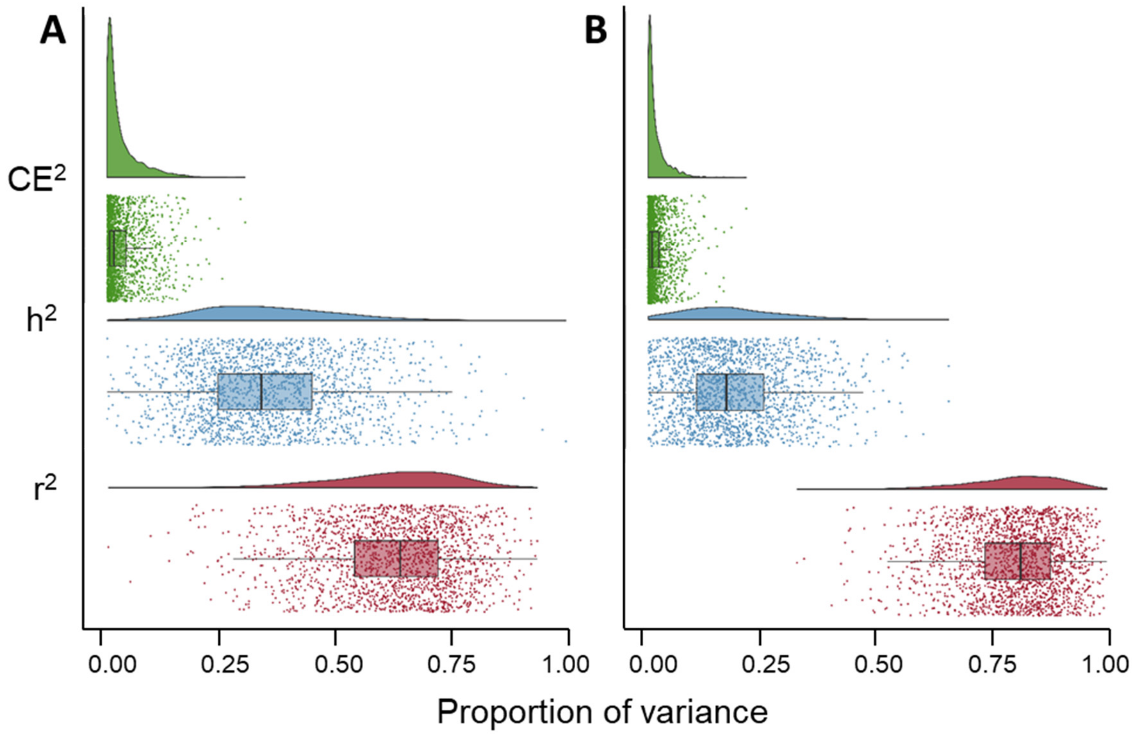

Figure 1 Heritability (h^2, blue), common environment effect (CE^2, green) and residual variance (r^2, red) of protein efficiency of the whole body **(A)** and protein efficiency of the carcass **(B)**. Posterior distributions of the respective variance components (upper part), points representing single estimates are shown together with a box plot (with median, interquartile range and 5th to 95th percentile range).

We found a low negative phenotypic correlation of *NEffEB* and the number of days an animal was delayed in reaching target weight (Table 1). *NEffEB* correlated moderately positively with phosphorus efficiency. Body composition traits (water/crude ash/crude fat content) were not correlated with *NEffEB*.

Table 1 Correlations of *NEffEB* with traits of potential economic and ecological impact as well as with body composition.

trait	type	coefficient ± 95% CI
days delayed	Spearman	$\rho = -0.16\ [-0.26, -0.07]$
P efficiency	Pearson	$r = \quad 0.65\ [0.48, 0.77]$
water content	Pearson	$r = -0.07\ [-0.32, 0.18]$
crude ash content	Pearson	$r = -0.16\ [-0.39, 0.09]$
crude fat content	Pearson	$r = -0.14\ [-0.38, 0.11]$

Conclusion

Our preliminary results indicate a potential for selective breeding towards increased protein efficiency but more research is needed to improve estimates of genetic parameters. Information on the association of genetic loci (SNPs) and protein efficiency will help understand the genes and their functions that underlie protein efficiency. We found no major trade-offs with other economically important traits. Breeding for increased protein efficiency could lead to a slower growth of the animals, but the decrease is expected to be small and might be offset by lower costs of protein-reduced feed. However, potential trade-offs with fertility, aggression and meat quality should be addressed by future studies. A reduction of proteins in pig feed can potentially facilitate both conventional and organic pig production in Switzerland.

References

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