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Summary

The objective of this paper was to study the estimated breeding values (EBV) profiles for feed conversion ratio (FCR) over the growing period in eight generations of divergent selection for Residual Feed Intake (RFI) in Large White pigs. Data comprised 11790 weekly FCR collected on 1186 boars during a 10 week-period. A random regression model was used to estimate 10 week EBVs per animal. Then, the individual EBV trajectories were classified into subgroups using a *k*-means approach with a Euclidean distance. The responses to selection in the divergent lines (LRFI= low RFI; HRFI= high RFI) on the FCR dynamics were evaluated. On the one hand, the average weekly EBV over time per line and generation were considered; on the other hand the first two summarized breeding values (SBV1 & SBV2, representing the slope and the mean of the EBV curves, respectively) were computed for each individual from the eigendecomposition of the genetic covariance matrix between time points, and they were averaged for each line and generation. The results showed that individual EBV trajectories for FCR were classified into three distinct subgroups. These groups corresponded to early generations, late LRFI generations, and late HRFI generations, respectively. The more efficient pigs had smaller initial value of FCR and smaller slope of the EBV than less efficient pigs. The changes in SBV1 and SBV2 corroborated the evolution of the EBV curves for each line and generation. Further examination pointed out changes in the dynamics of growth rates associated to these responses. This study showed that selection for feed efficiency affected the dynamics of FCR during growth.

Keywords: longitudinal data, pigs, divergence selection, feed efficiency, residual feed intake

Introduction

Improving feed efficiency of pigs contributes to increased profitability of pig farming as well as reduction of its negative impacts on the environment (Patience et al. 2015, Gilbert et al. 2017). Feed conversion ratio (FCR = daily feed intake/average daily gain) and residual feed intake (RFI; difference between observed feed intake and expected feed intake for maintenance and production requirements) are two measures of feed efficiency. The RFI permits to select animals that consume less without affecting growth traits. Selection for RFI has resulted in an improvement of FCR at the phenotypic and the genetic levels (Gilbert et al., 2017). However, little is known about the effect of selection on the dynamics of feed efficiency over the growing period. The analysis of repeated records can improve estimations in a genetic selection context for feed efficiency compared to simple trait analyses (Boligon et al., 2011). With the development of automatic self-feeders, individual feed intake and body weight values (and thus FCR) can be measured repeatedly during the growing period in groups of animals. For RFI, records require measurement of body composition to evaluate production requirements variability due to differences in protein/lipid distribution, which is usually not measured repeatedly. To evaluate the impact of selection for RFI on the dynamics of feed efficiency during growth, we studied the evolution of the estimated breeding values (EBV) profiles for FCR in divergent lines for RFI.

Material and methods

Pigs and data collection

The present study includes data from 1186 growing Large White boars over 8 generations raised after weaning in the Rouillé INRA experimental farm (GenESI, Vienne, France). From the initial generation (G0), the lines were divergently selected for RFI to produce animals with low RFI (LRFI, corresponding to more efficient animals) and high RFI (HRFI, corresponding to less efficient animals). The genetic selection process has been described in details by Gilbert et al. (2007). Pigs were tested during the growing-finishing period from 67 ± 1 day (25 ± 4 kg) to 168 ± 13 days (115 ± 11 kg). They had individual measurements for body weight (BW) every week and for feed intake (FI) every day. From the 14-week test, weekly FCRs were calculated according to Huynh-Tran et al. (2017a), resulting in 11790 weekly FCR values over 10 weeks. A total of 3986 animals were included in the pedigree.

Statistical analyses

The 10 repeated measurements of FCR were analyzed using a random regression model with polynomial of order 2 for both genetic and permanent environmental effects. The fixed effects included in the model were the week of observation (10 levels), the pen within batch (96 levels), the batch of birth (32 levels), the age and BW of the animal at the beginning of the test. Covariance components and breeding values were estimated by the restricted maximum likelihood (REML) method using the ASRemL software (Gilmour et al., 2009).

As a result of the genetic models, we obtained 10 weekly EBVs for FCR per animal. The patterns of EBV changes over time were then described using a trajectory classification approach that classified animals into different trajectory groups using a *k*-means approach with a Euclidean distance (Genolini et al., 2015). This trajectory classification was proposed to visualize the changes of animal profiles as a result of the selection on RFI. Next, the 10-EBVs vector for each animal was summarized in a reduced number of independent summarized breeding values (SBV). For animal *i*, SBVp_i was obtained by multiplying the p^{th} eigenvector of the eigendecomposition of the estimated genetic covariance matrix between times (**G**) with the vector of 10 week $\boldsymbol{EBV}_i$. As shown in Huynh-Tran et al. (2017b), SBV_1 and SBV_2 are related to the slope and mean of the EBV curves, respectively. SBV1 and SBV2 were averaged per line and generation to assess the evolution of the dynamics of weekly EBV for FCR in response to selection for RFI.

Results and discussion

The trajectory classification approach identified three subgroups of individual EBV trajectories, as shown in **Fig. 1.** The first group consisted in a low initial value and continuous increase over time with a weak slope (35.4 % of the pigs, group noted A). The second group also reflected an increase of the EBV over time but with a steeper initial slope and higher initial value (34.6% of the animals, group noted B). The last EBV trajectory pattern reflected a constant EBV over time (30.0% of the animals, group noted C). This classification is strongly related with the selection for RFI : the EBV trajectories of the animals from the first three generations belonged to group C, pigs from generations 4 to 7 of the LRFI line belonged to group A, and animals from generations 4 to 7 of the HRFI line to group B (Fig. 1). These results suggested that selection for RFI strongly impacted the FCR curves during the test. Altogether, the FCR curve shapes supported that pigs are more efficient to convert feed into meat at the earlier ages than at the end of the test as previously reported by Shirali et al. (2012).

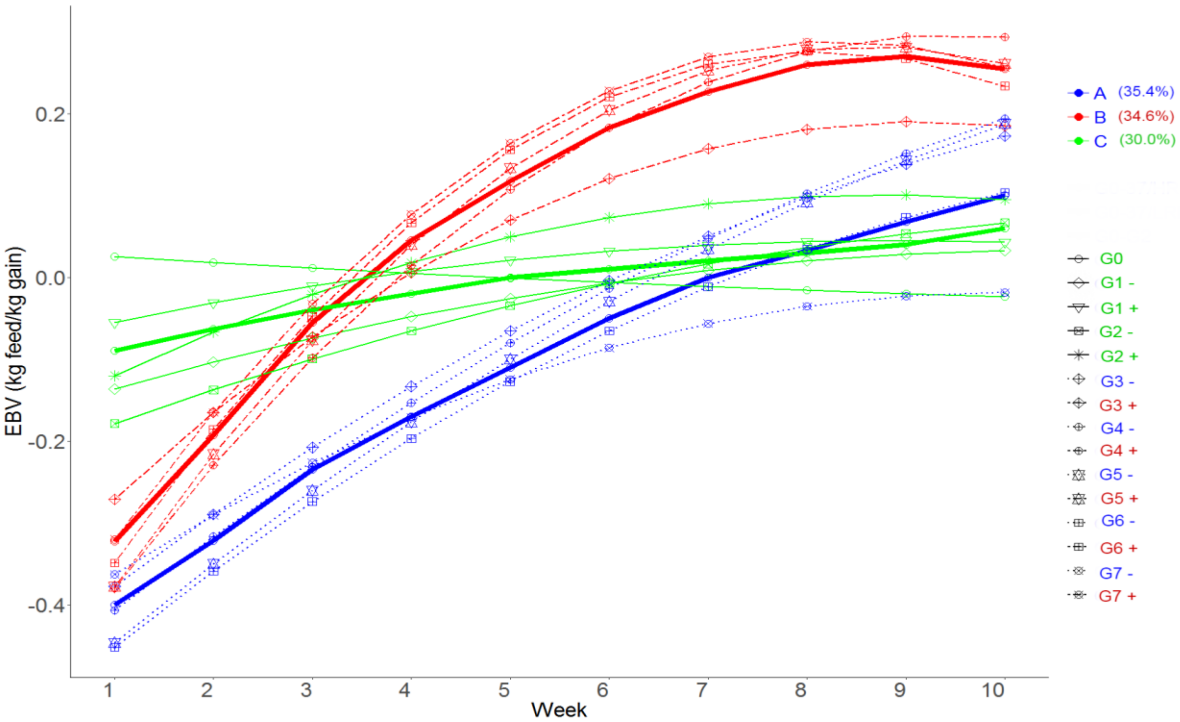

Figure 1. Mean EBV trajectories per line and generation obtained with a random regression model during the test for the RFI lines. The solid green lines (group C) are the EBV trajectories of pigs from generations G0, G1, G2, the dotted blue lines (group A) are the EBV trajectories of pigs from generations G3 to G7 of the low RFI line; the dotdashed red curves (group B) are the EBV trajectories of pigs from generations G3 to G7 of the high RFI line. The bold lines are the mean curve of group A, B and C, respectively.

To better describe how selection for RFI affected the FCR trajectory, changes in SBV1 and SVB2 per line and generation are presented in Fig. 2. The SBV2, which is strongly correlated to the mean of EBV trajectories (0.96, Huynh-Tran et al, 2017b) quasi-linearly decreased for LRFI line (from -0.13 for G1 to -0.51 (kg feed/kg gain) for G7) and increased for HRFI line (from 0.015 for G1 to 0.17 for G7). This result was in line with the study of Gilbert et al. (2017) that reported significant response to selection on FCR over the whole test-period in these lines.

The SBV1, associated with the slope of the EBV trajectories (Huynh-Tran et al, 2017b), increased from G0 to G5, then decreased until G7 for LRFI line. Meanwhile, SBV1 increased from G0 to G4, then slightly decreased from G5 to G7 for the HRFI line. As a result, slopes of the FCR curves remained similar between lines until G3, then the slopes started diverging , the decrease of feed efficiency with time being higher in the HRFI line in comparison with the LRFI line. These results show that selection for RFI impacted the FCR curves during the test. Since FCR is a ratio, differences in changes in FCR over time between lines maybe related, as suggested by Saintilain et al. (2015), to differences between lines in changes in FI, ADG or both.

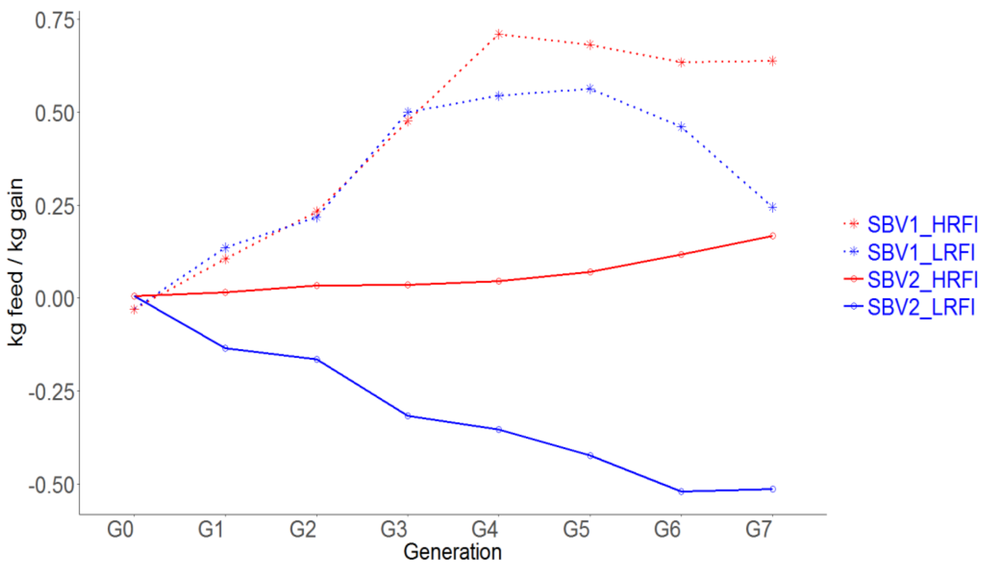

Figure 2 : Change of the summarized breeding values during 8 generations (G0 to G7). SBV1_LRFI (SBV1_HRFI), SBV2_LRFI (SBV2_HRFI): first and second summarized breeding values for feed conversion ratio (FCR) obtained from the genetic covariance matrix ***G*** *with a random regression model for the low residual feed intake line (LRFI)(high residual feed intake line (HRFI)).*

So, to further understand the differences in FCR curves between lines, the phenotypic FI and ADG curves were also examined per line and generation (results not shown). We observed the same shape of FI curve over time for both lines, with a change of magnitude due to the generations (LRFI pigs eating less feed every week than HRFI pigs). For ADG, the pattern of the ADG curves changed with the selection. The ADG curves of the first three generations (G0 to G2) were similar for both lines. From G3, the ADG patterns changed between lines. The LRFI pigs had a lower growth rate for the earlier periods and higher growth rate for the later period than the HRFI pigs. A similar difference was reported at the phenotypic level by Saintilan et al. (2015), who reported faster growing animals in the less efficient group at the beginning of the test, and faster growing animals in the more efficient group at the end of the test-period. It has been shown that this difference in growth rate is associated with difference in lipid to protein deposition ratio between the divergent RFI lines (Gilbert et al., 2017), resulting in increased leanness in the LRFI pigs.

Conclusion

This study showed that selection based on RFI had an impact on the dynamics of the FCR over time.

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