Estimation of Genetic Parameters for Growth and Feed Efficiency Traits in Two Commercial Rabbit Lines.

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ABSTRACT: Genetic parameters of growth and feed efficiency were estimated in two rabbit commercial lines. Heritability estimates for growth traits were low to moderate, and slightly higher in the AGP39 line than in the AGP59 line due to slightly higher common litter environment effects. Heritability estimates of feed efficiency were slightly higher in the AGP59 line than in the AGP39 line (0.40 and 0.42 for feed conversion ratio; 0.29 and 0.33 for residual feed intake (RFI), respectively, with standard errors between 0.05 and 0.07). In the AGP39 line, RFI was genetically independent from weaning weight, body weight at 63 days and average daily gain, whereas in the AGP59 line, RFI tended to be unfavourably correlated with body weight at 70 days and average daily gain. In both lines, RFI was positively correlated with feed conversion ratio (about 0.87±0.03), suggesting good opportunity for improving feed efficiency with RFI.

Keywords:
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Introduction

Feed represents about 60 % of production costs for rabbit breeding in France. Improvement of feed efficiency will contribute to increase the competitiveness of the rabbit industry but also to reduce animal excretion, and consequently decrease the environmental impact of the production. Improvement of feed efficiency can be achieved by selection directly on feed to body weight gain ratio, or on residual feed intake which represents the fraction of total feed intake that is unexplained by maintenance requirements and growth needs, as demonstrated in previous studies in rabbits (Larzul and De Rochambeau 2005; Drouilhet *et al.* 2013). This study presents genetic parameters of growth and feed efficiency traits in two paternal commercial lines of the Hypharm breeding company.

Materials and methods

Animals management. The survey included 3714 rabbits from the AGP39 line and 3602 rabbits from the AGP59 line. In the first litter of each dam, four kids were randomly chosen after weaning at 31 days of age and reared in individual cages. Rabbits were fed *ad libitum* a commercial pelleted diet until the end of the growing period, at 63 days for the AGP39 and at 70 days for the AGP59. Individual body weights (BW) were measured at weaning (BW31) and at the end of the test (BW63 for AGP39; BW70 for AGP59). Average daily gain (ADG) was obtained by dividing the body weight gain during the test by the number of days of the growing period. Individual feed intake during the test (FI) was recorded manually as the difference between weight of feed delivered and refusals. Feed conversion ratio (FCR) was calculated as total feed intake divided by the body weight gain.

Statistical analysis. Residual feed intake (RFI) was computed as the residual of the multiple linear regression of total feed intake on average metabolic body weight (average body weight between weaning and end of the test to the power 0.75) to account for maintenance requirements and ADG to account for production requirements (REG procedure; SAS software). The genetic parameters were estimated by the REML methodology applied to an animal model, using the ASReml Software (Gilmour *et al.* 2009). Bivariate analyses were performed for all pairs of traits to estimate the genetic parameters. Fixed effects retained in the model for all traits were batch, sex and litter size at weaning. The random effects of the common environment of the litter and of the animal additive effects were also included in the model. The pedigree file included 6834 animals for the AGP39 line and 6067 animals for the AGP59 line.

Results and discussion

Computation of RFI. Descriptive statistics of traits are given in table 1. In the AGP39 line, the regression equation was: $FI(g) = -1375 + 1.55*ADG(g/day) + 14.2*(average\ BW(g))^{0.75} + RFI$ (R^2=0.74). In the AGP59 line the regression equation was: $FI(g) = -1626 + 1.36*GMQ(g/day) + 15.3*(average\ BW(g))^{0.75} + RFI$ (R^2=0.67).

Variance components estimations. Heritability estimates of the traits analyzed are given in table 2 and table 3. Heritability estimates for BW and ADG were slightly higher in the AGP39 line (from 0.22 ± 0.05 to 0.24 ± 0.08) than in the AGP59 line (from 0.12 ± 0.05 to 0.17 ± 0.08). For feed efficiency traits, heritability estimates tended to be higher in the AGP59 line (0.42 ± 0.06 for FCR and 0.40 ± 0.07 for RFI) than in the AGP39 line (0.33 ± 0.06 for FCR and 0.29 ± 0.07 for RFI). These differences were related to slightly larger variance components for the common environment of the litter for growth traits in the AGP59 line, and for feed efficiency traits in the AGP39 line. Moreover, the proportion of variance explained by the common litter environment effect was larger for earlier BW records (0.44 ± 0.04 and 0.52 ± 0.04 for BW31 for AGP39 and AGP59, respectively) than for later BW records (0.22 ± 0.06 for

BW63 for AGP39 and 0.27 ± 0.03 for BW70 for AGP59).

Heritability estimates for BW31 of both lines were in accordance with values reported by Garcia and Baselga (2002) (0.22 ± 0.009) but higher than those given by Lukefahr *et al.* (1996) (0.04), Larzul and de Rochambeau (2005) (0.09 ± 0.13) and Drouilhet *et al.* (2013) (0.06 ± 0.04). Heritability estimate for BW63 in the AGP39 line (0.24 ± 0.06) was in agreement with values reported by Garcia and Baselga (2002) (0.30 ± 0.013) and Larzul *et al.* (2005) (0.22 ± 0.02). In the AGP59 line, the heritability of BW70 was lower and close to values reported by Lukefahr *et al.* (1996) (0.12) and Drouilhet *et al.* (2013) (0.14 ± 0.05). Heritability estimates for ADG in the literature vary considerably: 0.11 ± 0.02 (Piles and Blasco 2003), 0.17 (Lukefahr *et al.* 1996), 0.22 ± 0.06 (Garcia and Baselga 2002; Drouilhet *et al.* 2013), 0.41 ± 0.13 (Larzul and De Rochambeau 2005). Our estimates were in the range of these values. Heritability estimates for FCR in our study were rather high in comparison to the values available in the literature: 0.25 ± 0.12 (Piles *et al.* 2004), 0.27 (Larzul and De Rochambeau 2005) and 0.22 ± 0.05 (Drouilhet *et al.* 2013). Heritability estimates for RFI were closer to that reported by Larzul and de Rochambeau (2005) (0.45 ± 0.11) than to that given by Drouilhet *et al.* (2013) (0.16 ± 0.05). In pigs heritability estimates for RFI range from 0.10 to 0.42 (Clutter 2011). In this species, RFI is most often estimated taking into account ADG and backfat thickness (Saintilan *et al.* 2013). In the rabbit, the low adiposity of growing animals does not allow an accurate estimation of the part of feed intake dedicated to fat deposition in the prediction equation of feed intake (Larzul and De Rochambeau 2005).

Estimates of the common litter environment were larger for BW31 than for BW63 and BW70. Due to the decrease of maternal effects with time, this tendency was previously described in several studies (Ferraz and Eler 1994; Garcia and Baselga 2002; Larzul and De Rochambeau 2005; Larzul *et al.* 2005).

Tables 4 and 5 show the genetic correlations between the traits in the two lines. In the AGP39 line, the correlation between BW31 and BW63 was positive (0.53 ± 0.21). The ADG was strongly correlated with BW63 (0.70 ± 0.08) and not significantly correlated with BW31. The FCR tended to be unfavorably correlated with BW31 (0.46 ± 0.29). It was genetically independent from BW63 but favorably correlated with ADG (-0.37 ± 0.26). The RFI was not significantly correlated with growth related traits, but it was strongly correlated with FCR (0.88 ± 0.03).

In the AGP59 line, the correlation between BW31 and BW70 was also positive (0.59 ± 0.22). Like in the AGP39 line, ADG was strongly correlated with BW70 (0.81 ± 0.08) but not significantly correlated with BW31. The FCR was unfavorably correlated with BW31 (0.65 ± 0.26) and tended to be also unfavorably correlated with BW70 (0.52 ± 0.25). Nevertheless FCR was not significantly correlated with ADG. Contrary to the AGP39 line, RFI tended to be unfavorably correlated with BW70 (0.43 ± 0.27) and with ADG (0.44 ± 0.22). As in the AGP39 line, RFI was strongly positively correlated to FCR (0.87 ± 0.02).

In the AGP39 line, the genetic correlations between FCR and growth traits were very similar to those previously reported by Drouilhet *et al.* (2013) (-0.11with BW63 and -0.38 with ADG). This result indicates that a selection for ADG would allow a moderate genetic gain in FCR. It is difficult to explain the unfavorable correlations between FCR and growth traits in the AGP59 line, as there are no equivalent results in the literature. However, due to the relatively large SE for these estimates in our study, further validation is needed for this tendency.

The very high estimates of correlation between RFI and FCR were in accordance with the values reported by Drouilhet *et al.* (2013) (0.96) and by Larzul et De Rochambeau (2005) (1.00). In pigs, genetic correlations between RFI and FCR are also strong (de 0,52 à 0,85, Saintilan *et al.* 2013), and seem to be stronger in leaner genotypes. These estimations indicate that selection for low RFI has the potential to improve FCR, especially in lean genotypes.

Another strategy to improve feed efficiency is to select for increased ADG under restricted feeding during the growing period (Drouilhet *et al.* 2013). This criterion is indeed heritable (0.22 ± 0.06) and mechanically strongly correlated with FCR (-1.00). Such a selection was applied to pigs (Nguyen *et al.* 2005). The authors showed an improvement of feed efficiency with an increase of growth rate and a decrease of spontaneous intake, even when animals were fed *ad libitum*. A second advantage of this strategy is the favorable effect of restrictive feeding on gut health after weaning (Gidenne *et al.* 2012). However the major difficulty is to individually control the feeding restriction.

Conclusion

To our knowledge, this is the first published estimation of genetic parameters of feed efficiency in rabbit commercial lines. Heritability estimates of feed conversion ratio and residual feed intake show that these traits are heritable when recorded in commercial conditions, so significant genetic gains can be expected for these traits. The expected correlated responses on growth traits, but also on reproductive performances, should be further examined to propose selection strategies including all the breeding objectives in rabbits.

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Table 1. Descriptive statistics in the AGP39 and in the AGP59 lines.

	AGP39		AGP59	
Trait	mean	STD	mean	STD
Body weight at 31 days, g	864	153	833	141
Body weight at 63 days, g	2859	283	/	/
Body weight at 70 days	/	/	3261	336
Average daily gain, g/day	60	6	61	7
Feed intake, g	5720	711	7076	902
Feed conversion ration	2,88	0,24	2,91	0,23

Table 2. Heritability estimates (h^2) and common litter effect (c^2) in the AGP39 line.

Trait	h^2	c^2
BW31	0.24 (0.08)	0.44 (0.04)
BW63	0.24 (0.06)	0.22 (0.06)
BW70	/	/
ADG	0.22 (0.05)	0.09 (0.02)
RFI	0.29 (0.07)	0.13 (0.03)
FCR	0.33 (0.06)	0.07 (0.02)

Table 3. Heritability estimates (h^2) and common litter effect (c^2) in the AGP59 line.

Trait	h^2	c^2
BW31	0.17 (0.08)	0.52 (0.04)
BW63	/	/
BW70	0.14 (0.06)	0.27 (0.03)
ADG	0.12 (0.05)	0.12 (0.02)
RFI	0.40 (0.07)	0.06 (0.02)
FCR	0.42 (0.06)	0.07 (0.02)

Table 4. Estimates of genetic correlations (standard errors of estimates) in the AGP39 line.

	BW31	BW63	ADG	FCR
BW63	0.53 (0.21)			
ADG	0.09 (0.23)	0.70 (0.08)		
FCR	0.46 (0.29)	0.00 (0.27)	-0.37 (0.26)	
RFI	0.02 (0.27)	-0.07 (0.23)	-0.14 (0.31)	0.88 (0.03)

Table 5. Estimates of genetic correlations (standard errors of estimates) in the AGP59 line.

	BW31	BW70	ADG	FCR
BW70	0.59 (0.22)			
ADG	0.17 (0.35)	0.81 (0.08)		
FCR	0.65 (0.26)	0.52 (0.25)	0.22 (0.24)	
RFI	0.22 (0.25)	0.43 (0.27)	0.44 (0.22)	0.87 (0.02)