Genetic Relationship Between Residual Feed Intake Of Growing Bulls And Adult Cows

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Introduction

Residual feed intake is currently measured and selected in the performance testing stations of AI sires in France not only for a direct response in decreasing the production costs of beef cattle fattening, but also to get a correlated modification of body gain composition in favor of muscle against fat (Renand, Fouilloux, Ménissier, 1998). With about ⅔ to ¾ of total feed costs for beef production being spent for the breeding cow herd, it is essential to know if this selection criterion is related and useful to reduce the feed wasting by adult cows. Few experimental results can be found in the literature (Archer, Reverter, Herd *et al.* 2002). Results obtain during two decades in an INRA experimental herd were analyzed and genetic parameter estimates are presented to set breeders straight about this question.

Material and methods

Animals and traits. In five consecutive years, 510 Charolais young bulls entered two central test stations at 10 months of age and, after an 8 week adaptation period, were controlled during 18 weeks. They were fed a moderate energy pelleted ration (10 MJ ME, 16% protein and 18% crude fiber/kg dry matter). Daily feed intake (FI_s) was recorded with automate feeders. Average daily gain (ADG_s) and mid-test weight (MW_s) were recorded. Residual feed intake (RFI_s) was estimated as the residual of the regression of FI_s on MW_s and ADG_s.

Each year, in each station, six bulls were selected on a synthetic index combining positively the final test weight and negatively the residual feed intake (3 among the top and 3 among the bottom ranking bulls). The 60 selected sires were used, jointly with 22 other sires, to procreate purebred Charolais calves in an INRA experimental farm. After weaning at 32 weeks of age, the male calves were fed *ad libitum* with a pelleted ration similar to the ration used to test the sire generation. After a transition period of 7 weeks, average daily gain (ADG_b), mid-test weight (MW_b) and daily feed intake (FI_b) of 1340 young bulls were recorded during a 30 week test period. Residual feed intake (RFI_b) was estimated as the residual of the regression of FI_b on MW_b and ADG_b.

The female progeny were kept for replacement and controlled over 4 breeding years. Two weeks after the last drying up, 472 non pregnant cows aged 6,6 years on average entered the feeding control barn where they were fed *ad libitum* with natural grassland hay. After 3

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weeks of adaptation, feed intake of dry matter (FI_c) was daily controlled during 4 weeks and average daily gain (ADG_c) and mid-test weight (MW_c) were recorded. Residual feed intake (RFI_c) was estimated as the residual of the regression of FI_c on MW_c (see below).

Statistical analyses. The sire, young bull and adult cow traits were first analyzed separately to estimate the phenotypic standard deviations and correlation coefficients. The sire generation traits were fitted in a model with a contemporary group effect (year x station). The model for the young bull traits was fitted with the following effects: control year (19 levels), parity of the dam (5 levels) and twinning status (6% twins). The model for the adult cows included only the year control effect (15 levels). The residual of these models were used to estimate the residual standard deviations (RSD), the phenotypic correlation coefficients and the regression coefficients of FI on both MW and ADG. Only significant regression coefficients were kept to estimate the RFI.

The eight traits were analyzed jointly in a single multitrait animal model that included the above mentioned fixed effects and 8800 genetic additive effects: 2322 animals with performance and 6478 ancestors up to 4 generations. Variance components and genetic parameters were estimated by the restricted maximum likelihood (REML) methodology using the VCE 4.2.5 software (Neumaier and Groeneveld 1998).

Results and discussion

Average performances are reported in Table 1 for the three animal samples. In comparison to growing bulls, the feed intake was highly variable among culled cows (Table 1). The variability of feed intake capacity is obviously maximized with roughage ration. The quality of the hay was chosen to cover essentially the maintenance requirements of the cows and to permit only a limited weight gain. The daily gain was actually lower than 400 g/day and was not significantly different from zero due to the large variability among cows (a possible consequence of the short control duration).

Table 1: Performances* of the sire generation and of the male and female progeny

Traits		Sire generation	Young bulls	Adult cows
FI	kg/day	11.67 ± 0.87	10.39 ± 1.15	12.03 ± 2.66
MW	kg	638 ± 38	473 ± 40	707 ± 65
ADG	g/day	1412 ± 212	1551 ± 188	392 ± 592

* mean ± phenotypic s.d..

The phenotypic correlation coefficients between feed intake, mid-test weight and daily gain are reported in Table 2. For the growing bulls of both generations, FI was highly related to live weight and growth rate: 69% and 53% of the phenotypic variability of FI_s and FI_b was explained by MW and ADG. The phenotypic s.d. of RFI was 0.48 kg/day for sires and 0.79 kg/day for bull progeny. For culled cows, FI_c was independent of weight gain. The cow RFI_c was therefore estimated as the residual of the regression of FI_c on MW_c only. The RFI_c phenotypic s.d. was 2.57 kg DM/day and was expected to be mainly related to body maintenance requirement and energy wasting differences.

Table 2: Phenotypic correlation coefficients between feeding performances

Traits	Sire generation	Young bulls	Adult cows
FI- MW	0.79	0.67	0.25
FI- ADG	0.53	0.55	0.00
MW- ADG	0.37	0.43	0.04

The genetic parameters of mid-test weight, daily gain and residual feed intake are reported in Table 3 for growing bulls. The genetic correlation between the same trait recorded in the sire or the progeny generation are highly positive (r_g from +0.57 to +0.87) demonstrating these traits are largely controlled by a common set of genes, but not all the same genes. Genetic parameters of progeny traits are more precisely estimated than sire traits due to the genetic structure and environment differences. While heritability coefficients of MW_s and RFI_s are respectively high (h^2=0.62) and low (h^2=0.15), heritability coefficients are homogenous (h^2 = 0.33 on average) among progeny traits, similarly to results found by Arthur, Renand and Krauss (2001) on a subset of this experimental population.

Table 3: Genetic parameter estimates of growing sire and bull performances*

Male	Sire generation traits			Young bull progeny traits		
traits	MW_s	ADG_s	RFI_s	MW_b	ADG_b	RFI_b
MW_s	0.62±0.08	+0.41±0.08	+0.37±0.17	+0.57±0.08	+0.56±0.06	+0.18±0.08
ADG_s		0.37±0.08	+ 0.17±0.28	+0.40±0.10	+0.87±0.05	- 0.15±0.09
RFI_s			0.15±0.09	+ 0.14±0.10	+ 0.20±0.21	+0.64±0.18
MW_b				0.33±0.03	+0.25±0.09	+0.18±0.08
ADG_b					0.30±0.03	- 0.18±0.09
RFI_b						0.36±0.03

*Heritabilities (±s.e.) on the diagonal, genetic correlations (±s.e.) below the diagonal.

Heritability coefficients of cow traits are markedly different. The high heritability of MW_s (h^2= 0.77±0.02) is similar to the heritability estimated by Jaffrezic, Venot, Laloë *et al.* (2004) in this herd for cow weight at 5.5 years of age using a structured antedendence model. The heritability coefficient estimate of RFI_c is low (h^2= 0.09±0.02). This low value indicates that direct selection on RFI_c of dry and non pregnant adult cows will be poorly effective although this trait displays a large genetic variability. The genetic s.d. of RFI_c is indeed 0.77 kg DM/day, i.e. 6% of the daily feed intake of cows, slightly higher than the genetic s.d. of RFI_b that is 0.45 kg/day, i.e. 4% of the daily feed intake of growing young bulls. The difficulty to record roughage intake and the poor heritability of this trait require finding an indirect selection criterion for reducing the feed wasting by adult cows. It would be desirable that the genetic correlations between RFI of adult cows and RFI measured on seedstock bulls in a postweaning test were high.

The genetic correlation between RFI_c and weight cows is null (rg= -0.06±0.11) and the genetic correlations of these two traits with growing bull traits are reported in Table 4. Adult cow weight is highly correlated with growth traits of young bulls. Any selection to increase growth capacity of young bulls will consequently increase adult cow weight.
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Table 4: Genetic correlation estimates between performances of adult cows and performances of growing sires or bulls*

	Sire generation traits			Young bull progeny traits		
Cow traits	MW_s	ADG_s	RFI_s	MW_b	ADG_b	RFI_b
MW_c	+0.71±0.05	+0.87±0.05	+ 0.37±0.19	+0.51±0.07	+0.76±0.06	+0.13±0.07
RFI_c	- 0.02±0.12	- 0.36±0.16	- 0.21±0.12	+0.06±0.12	- 0.62±0.10	- 0.02±0.11

* Genetic correlations (±s.e.)

The genetic correlation coefficients between RFI_c and RFI_s or RFI_b are not significantly different from zero. These traits appear to be genetically independent: the physiological mechanisms controlling the feed efficiency of growing bulls are poorly related to those controlling feed wasting of the adult cow when this cow has no production needs. This result is important since the measurement of feed intake with automate feeder in order to select feed efficiency of performance tested bulls won't lead to a correlated reduction of feed wasting by adult cows. This result clearly belies the conclusions of Archer, Reverter, Herd *et al.* (2002) who suggest that measurements of feed efficiency of growing animals may be used to improve feed efficiency of mature cows. However, in the experiment they reported, they estimated the genetic correlation between RFI of growing heifers and adult cows (dry and non pregnant) that were fed the same pelleted ration allowing a 1.2 kg/day daily gain for adult cows, i.e. a ration much above the maintenance requirements.

Conclusion

This experiment is the first intended to estimate the genetic relationship between feed efficiency of growing bulls and adult cows when feed intake of these dry and non pregnant cows is essentially related to maintenance requirements using a low energy roughage ration. The results show that no reduction of the RFI of adult cows can be expected when selecting against RFI of growing bulls. The genetic determinism of efficiency of adult cows at maintenance appears different to that of growing bulls.

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