Genetic associations between feed efficiency measured in a performance test station and performance in commercial beef herds

J.J. Crowley[*‡], N. McHugh[*‡], R.D. Evans[†] and D.P. Berry[*]

Introduction

There is an ever increasing interest in improving feed efficiency in cattle through improvements in animal management and genetics. Significant genetic variation in feed efficiency and other traits has been reported previously using data from performance test stations (Arthur *et al.* (2001); Crowley *et al.* (2010)). However, the correlated response in commercial herds to selection on feed efficiency measured in performance test stations is less well investigated, especially where differences in production systems exist between commercial farms and performance test stations. For example, in Ireland, performance tested bulls are fed a high energy concentrate diet (Crowley *et al.* (2010)) whereas on commercial farms, grazed or ensiled grass constitute the basal diet of cattle. Furthermore, genetic selection on some feed efficiency variables using traditional methods of genetic evaluation is limited by routine access to necessary phenotypes such as feed intake. Indirect selection on routinely recorded traits such as linear type traits may overcome the limitations of the lack of routinely available phenotypic data and thereby enable indirect selection. The objective of this study was to quantify the genetic association between a range of definitions of feed efficiency and other performance traits measured during performance testing and linear type traits, animal value and carcass traits recorded in commercial herds.

Material and methods

Performance test animals. The performance testing procedures are described in detail by Crowley *et al.* (2010). Concentrate intake (CI) and bodyweight (BW) records for the animals included in the present study were available on 3,605 bulls from the national beef bull performance test centre at Tully, Kildare, Ireland from September 1983 to February 2007, inclusive. Data edits, feeding regimes and diets are outlined in detail by Crowley *et al.* (2010). Average daily gain (ADG) during the test period for each bull was calculated by fitting a linear regression through all BW observations of each bull. Mid-test BW (MWT) was taken as BW 35 days prior to the end of the test which was estimated from the intercept and slope of the regression line. Similarly mid-test metabolic BW (i.e., $MWT^{0.75}$) was estimated from the intercept and slope of the regression line after fitting a linear regression through all metabolic BW observations. Mean daily CI was calculated as the arithmetic mean daily intake, on a fresh basis, across the test period. Feed conversion ratio (FCR) was

[*] Moorepark Dairy Production Research Center, Fermoy, Co. Cork, Ireland
[†] Irish Cattle Breeding Federation, Highfield House, Bandon, Co. Cork, Ireland
[‡] School of Agriculture, Food Science & Veterinary Medicine, University College Dublin, , Dublin 4, Ireland

calculated as average CI divided by ADG. Residual feed intake (RFI) was assumed to represent the residuals from a multiple regression model regressing CI on ADG and $MWT^{0.75}$ with a contemporary group effect included. Similarly, residual gain (RG) was assumed to represent the residuals from a multiple regression model regressing ADG on CI and $MWT^{0.75}$ with a contemporary group effect in the model.

Linear type traits. Live animal linear scores of 42,683 commercial animals scored between the years 2005 and 2008 were available. The subjective measurements taken, based on the French 'Pointage' system, included a variety of skeletal and muscle traits (Table 1). Data for each trait were standardised within scorer by year to a common variance within trait. Animals with an unknown sire and animals with more than 25% of their breed fraction unknown were discarded. Only animals with Aberdeen Angus (AN), Belgian Blue (BB), Charolais (CH), Friesian (FR), Hereford (HE), Holstein (HO), Limousin (LI) and Simmental (SI) breed fractions were retained. Contemporary groups was defined as herd-date of scoring. After all edits, 44,827 animals with linear scores remained.

Animal price. Price data on 2,506,110 animals, split into three different maturity categories characterised as calves (<84 days of age), weanlings (aged 6 to 12 months of age) and post-weanlings (12 to 30 months of age for females; 12 to 36 months for males), between 2000 and 2008 were used. Animals with an unknown sire and animals with more than 25% of their breed fraction unknown were discarded. Only animals with AA, BB, CH, FR, HE, HO, LM or SI breed fractions were retained. Two contemporary groups were defined: auction venue by date and herd-year-season of sale. After all edits, 34,660 calves, 10,385 weanlings and 21,812 post-weanlings remained.

Carcass traits. Data on carcass conformation, carcass fat and carcass weight on 2,566,969 singletons slaughtered between 2005 and 2008 were available. In the present study the EUROP classification grades were transformed to a 15-point linear scale as outlined by Hickey *et al.* (2007). Similar to the linear type and price data, only animals with at least 75% of their breed fraction known which had to contain AN, BB, CH, FR, HE, HO, LM and SI breed fractions were retained. Contemporary group was defined as finishing herd by slaughter date. The final data set comprised of 96,671 animals.

Statistical analyses. Phenotypic and genetic (co)variance parameters were estimated using linear mixed animal models in ASREML (Gilmour *et al.* (2007)). Fixed effects used in the model for the traits measured in the performance test station were contemporary group, breed, dam parity, a quadratic effect of age of the bull and an interaction with breed. Fixed effects included in the model for carcass and linear traits were contemporary group, gender, non-linear association with age at slaughter, age by gender, parity of dam, breed proportion, heterosis and recombination loss. The fixed effects included in the models for price, common to maturity categories of calves, weanling and post-weanlings were: year of sale, month of sale, gender, age at sale, breed proportion, calving, whether the animal was born as a singleton or twin, heterosis and recombination loss. Parity of dam and dam age in months relative to the median age within parity, were also included as fixed effects. Additionally, for weanling and post-weanling price, the number of subsidies left to claim (0, 1 or 2) on the animal was also added as a fixed effect.

Results and discussion

Table 1: Genetic correlations (SE in parenthesis) between performance and feed efficiency traits in performance tested animals and skeletal and muscle linear type traits, economic traits and carcass traits in commercial animals.

	Scale	CI	MWT	ADG▲	FCR▼	RFI▼	RG▲
Height at Withers	1=Small 10=Tall	0.38 (0.09)	0.48 (0.08)	0.13 (0.12)	0.26 (0.12)	0.06 (0.11)	-0.03 (0.13)
Length of Back	1=Short 10=Long	0.39 (0.10)	0.54 (0.08)	0.33 (0.12)	-0.04 (0.13)	-0.11 (0.11)	0.23 (0.12)
Length of Pelvis	1=Short 10=Long	0.34 (0.12)	0.53 (0.09)	0.22 (0.14)	0.07 (0.15)	-0.05 (0.12)	0.11 (0.14)
Width of Hips	1=Narrow 10=Wide	0.06 (0.12)	0.31 (0.10)	0.10 (0.13)	-0.12 (0.14)	-0.22 (0.12)	0.13 (0.14)
Hind Quarter Development	1=Low 15=High	-0.04 (0.10)	0.13 (0.09)	0.16 (0.12)	-0.27 (0.12)	-0.25 (0.10)	0.24 (0.12)
Loin Development	1=Low 15=High	0.01 (0.11)	0.23 (0.10)	0.19 (0.12)	-0.32 (0.13)	-0.30 (0.11)	0.27 (0.13)
Thigh Width	1=Narrow 15=Wide	0.03 (0.11)	0.19 (0.10)	0.20 (0.12)	-0.25 (0.13)	-0.22 (0.11)	0.27 (0.12)
Width at Withers	1=Narrow 15=Wide	-0.01 (0.11)	0.25 (0.10)	0.16 (0.13)	-0.27 (0.13)	-0.33 (0.11)	0.25 (0.13)
Width Behind Withers	1=Narrow 15=Wide	-0.06 (0.11)	0.09 (0.10)	0.16 (0.13)	-0.33 (0.13)	-0.24 (0.11)	0.26 (0.13)
Calf Price	€	-0.18 (0.21)	0.17 (0.19)	-0.08 (0.24)	-0.21 (0.25)	-0.41 (0.21)	0.06 (0.25)
Weanling Price	€	-0.02 (0.19)	-0.01 (0.18)	-0.07 (0.21)	0.25 (0.22)	-0.01 (0.20)	-0.06 (0.22)
Post-weanling Price	€	0.12 (0.16)	0.43 (0.13)	0.45 (0.18)	-0.49 (0.18)	0.27 (0.18)	-0.45 (0.15)
Carcass Conformation	1=Poor; 15=High	-0.12 (0.12)	-0.10 (0.11)	0.15 (0.14)	-0.33 (0.14)	-0.19 (0.13)	0.28 (0.14)
Carcass Fat	1=Lean; 15=Fat	0.01 (0.14)	-0.33 (0.11)	-0.004 (0.16)	0.02 (0.17)	0.32 (0.14)	-0.06 (0.16)
Carcass Weight	kg	0.01 (0.11)	0.08 (0.10)	0.19 (0.13)	-0.29 (0.13)	-0.17 (0.12)	0.25 (0.13)

▲=Indicates where a (more) positive value for this trait is desirable; ▼= Indicates where a lesser value for this trait is desirable.

Linear type traits. Heritability estimates ranged from 0.18 to 0.34 for skeletal linear type traits and from 0.22 to 0.35 for muscular type traits. Absolute genetic correlations (Table 1) between ADG, CI and MWT and the skeletal linear type traits ranged from 0.06 to 0.54. Mid-test BW was correlated with muscularity; the genetic correlations with loin development and width at withers were 0.23 and 0.25, respectively. In general all muscularity type traits were correlated with FCR, RFI and RG indicating that selection for either of these feed efficiency traits will result in improved muscularity. The positive correlation between animal size (height at withers, length of back, height at withers, etc.) and both CI and MWT is not unexpected. A larger framed animal will, on average, weigh more and therefore also likely to have a greater maintenance requirement which must, on average, be met by a greater feed intake.

Animal price. Heritability estimates for price varied from 0.41 to 0.46. Excluding the feed efficiency traits, calf or weanling price were not correlated with any of the performance test measures (results not shown). However post-weanling price was correlated with both MWT (0.43) and ADG (0.45). The only correlations that were evident between the feed efficiency traits and price were those between post-weanling price and FCR (-0.49), RFI (-0.45) and RG (0.56). These correlations suggest selection for improved feed efficiency has a favourable impact on post-weanling price. This is not unexpected since FCR, RFI and RG are also favourably correlated with muscularity (Table 1).

Carcass traits. Heritability estimates for carcass conformation, carcass fat and carcass weight were 0.45, 0.25 and 0.53, respectively. Neither CI nor ADG were correlated with the carcass traits. Mid-test BW negatively correlated (-0.33) with carcass fat. Absolute genetic correlation between the feed efficiency traits and the carcass traits ranged from 0.02 (carcass fat and FCR) to 0.33 (carcass conformation and FCR). Selection for improved (i.e. lower) FCR is expected to improve both carcass conformation and carcass weight. Selection for improved (i.e. lower) RFI will lead to a leaner carcass and selection for improved (i.e. higher) RG will result in better carcass conformation.

Conclusion

Selection for improved feed efficiency will not have any unfavourable repercussions for linear type traits, animal price or carcass traits defined in this study. If anything selection for improved feed efficiency will result in better muscled animals, animals with a higher post-weanling value and animals with a larger, leaner carcass with better conformation.

References

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