GENOTYPE x ENVIRONMENT INTERACTIONS IDENTIFIED IN SOUTHERN AUSTRALIAN BEEF PRODUCTION

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SUMMARY

Data from the "Southern Crossbreeding Project" were utilised for the analysis of genotype by environment (G x E) interactions in a southern Australian production system. "Domestic heifers" were slaughtered for the domestic market at an average of 16 months (218kg Hot Standard Carcass Weight and 9.7mm rump fat at the P8 site) whilst "Export steers" were slaughtered for the export market at an average of 23 months (323kg HSCW and 14.7mm P8 fat). Performance of each sex was treated as a separate trait to assess the interaction between carcass traits at different market end points. Data were analysed using a univariate animal model containing the fixed effects of sex, sex x breed and sex x management group. Traits other HSCW were analysed on a weight constant basis by fitting HSCW × sex as a fixed effect. The random effects were animal (pedigree) for each sex resulting in a genetic variance for each sex and the correlation between heifers and steers (3 genetic and 2 residual variance components). For all carcass traits, the genetic correlation between market end points was less than one, although only significantly so for loin eye muscle area. It is not possible to determine the extent to which the significant interaction was the result of different weight endpoints, ages or differences between heifers and steers.

INTRODUCTION

Genotype by environment (G × E) interactions can arise due to both natural variations and management differences. If they are significant, this creates a potential industry issue if an individual's breeding performance is altered across environments (Falconer 1952). Data used in this study were obtained from The Southern Crossbreeding project, conducted in South Australia with calves born from 1994–1997. For this project, heifers and steers were slaughtered at different time points to meet both the domestic and export markets, respectively. The objective of this study was to analyse G × E interactions, defining the environment as the different market end points. In concurrence with previous studies (Johnston *et al.* 2003; Reverter *et al.* 2003), it was hypothesised that potential variation between market end points may be identified for certain traits, but no significant G × E interaction would be identified. Researching G × E interactions between market end points is important for producers because if G × E does exist between market endpoints, producers will have to select genotypes to match the market specifications to ensure maximum profit (Reverter *et al.* 2003).

MATERIALS AND METHODS

Animals and management. The project was conducted both at Struan Research Centre and Wandilo (a nearby property), in the south east of South Australia. The region is characterised by a Mediterranean climate. Jersey, Wagyu, Angus, Hereford, South Devon, Limousin and Belgian Blue sires were mated to Hereford cows in a top cross design (Pitchford *et al.* 2002). Calves were born at either Struan or Wandilo in three management groups. Calves were weaned at 9 months of

age in early January each year. Following weaning, all calves were managed at Struan where they were randomly allocated to between one and three post-weaning management groups (Pitchford *et al.* 2002). Calves were grown until 12 to 18 months of age and then transported to a commercial feedlot. The feedlot ration included a minimum of 60% grain with approximately 12 MJ ME/kg DM and 13% protein (Pitchford *et al.* 2002). The exception to this was the 1997 Export Steers that reached marketable weights without requiring grain finishing due to good available pasture.

Carcass traits. Heifers (n=636) were slaughtered for the domestic market at an average of 16 months (218kg hot standard carcass weight (HSCW) and 9.7mm P8 fat (rump fat depth at the P8 site)) whilst Export Steers (n=691) were slaughtered for the export market at an average of 23 months (323kg HSCW and 14.7mm P8 fat) at various commercial abattoirs throughout south eastern Australia. Carcass traits recorded included HSCW based on a standard trim (AUSMEAT, 1995), rump P8 fat, eye muscle area (EMA) and intra-muscular fat content (IMF). EMA was adjusted in relation to the site of quartering as per adjustments cited by Pitchford *et al.* (2006).

Statistical analyses. Analyses were conducted using ASREML 2.0 (Gilmour *et al.* 2000). Data were analysed using a univariate animal model containing the fixed effects of sex, sex × breed, sex × management group. HSCW × sex was fitted as a fixed effect for all traits excluding HSCW. The random effects were animal (pedigree) for each sex, resulting in a genetic variance for each sex and the correlation between heifers and steers (3 genetic and 2 residual variance components). An additional parameter estimated using CORH provided the genetic correlation between Domestic Heifers and Export Steers. Fat traits were log transformed because of scale effects on the variance. The likelihood ratio test statistic ($-2\Delta l$) (Kendall and Stuart, 1973), which is distributed as a χ^2 distribution, was used to test significance for values with 3.84 used as the threshold.

RESULTS

The raw means highlight that for the four traits analysed, males recorded greater values than females (Table 1). The differences reflect the market specifications each sex was slaughtered at. Heritabilities were calculated for the 4 carcass traits for both Export Steers and Domestic Heifers (Table 1). Heritability estimates for HSCW were high, especially for Domestic Heifers. Estimates were lower for IMF but moderate for the other traits analysed.

Table 1. Mean, phenotypic variance (V_p), heritabilities (h^2) and genetic correlations for traits analysed for Domestic heifers and Export steers. Significance was tested using the likelihood ratio test statistic which is distributed as a χ^2.

Trait	Domestic Heifers			Export Steers			Genetic Correlation	χ^2 prob.
	Mean	V_p	h^2	Mean	V_p	h^2		
HSCW	218	425.4	0.82	323	988.9	0.54	0.725	0.07
P8 Fat*	9.7	0.118	0.31	14.7	0.109	0.38	0.828	0.49
EMA	67.5	50.40	0.30	75.1	69.84	0.37	0.337	0.04
IMF*	3.72	0.088	0.21	5.34	0.111	0.15	0.999	0.96

* Data were transformed for analysis

Genetic Correlations. Genetic correlations for all traits measured are presented in Table 1. Robertson (1959) considered a genetic correlation above 0.8 to exclude G × E interactions. However, within this study we consider any genetic correlations less than unity to indicate some level of G × E interaction, with a significant interaction tested using the likelihood ratio test statistic. For the fat traits, the genetic correlation between Domestic Heifers and Export Steers was either close to (P8 fat) or unity (IMF). However, HSCW (P=0.07) and EMA (P<0.05) were less than unity.

DISCUSSION

In the absence of G × E interactions, breeders can be confident in their selection choices across a range of production systems. Alternatively, detecting G × E interactions allows for producers to be aware of the role of specific genotypes in their production environment.

Heritabilities estimated differed between Export Steers and Domestic heifers. However, generally heritabilities were in a similar range, with the exception of HSCW. For HSCW and IMF, domestic heifers had a higher heritability than export steers. Similarly, a trend for slightly higher heritabilities for domestic market carcasses (220 kg carcass weight) in comparison to export carcasses (>280kg carcass weight) was identified by Johnston *et al.* (2003). Actual heritabilities for the traits EMA and P8 fat differ between studies.

The genetic correlations identified for the traits in this project indicate that there are G × E interactions present between market end points in southern production systems for HSCW and EMA. The analysis, excluding HSCW as a covariate, identified that HSCW has a χ^2 probability of 0.07. Indicating a strong interaction between G × E for this trait. Although HSCW was not significant (P<0.05), the interaction for EMA was significant ($\chi^2 = 0.04$), proving a interaction between market endpoints for this trait. The G × E interaction identified between these two traits indicates differences in growth between the two cohorts. Arguably, males and females may have different muscular and skeletal patterns. However, the high level of G × E detected for EMA and HSCW was not detected in the other carcass traits (P8 fat and IMF).

In previous studies, there has been limited evidence of G × E interactions at different market end points. Johnston *et al.* (2003) and Reverter *et al.* (2003) found there was no significant genotype by environment interaction between three different market end points (220, 280 and 340 kg carcass weight) for both tropical and temperate breeds, concluding that the effect of genotype by market weight interactions was small. Johnston *et al.* (2003) attributed this to an increasing genetic expression of traits with increasing market weight, possibly reflecting increases in scale. In contrast with this current study, Johnston *et al.* (2003) analysed various carcass trait measurements at 3 different stages prior to slaughter, rather than at slaughter. Reverter *et al.* (2003) found some level of G × E interactions for fat colour (r_G=0.73) in temperate breeds and retail beef yield (r_G=0.53) in tropical breeds. Although this suggests G × E interactions at different market end points, Reverter *et al.* (2003) suggest these results may be due to other factors, for example differences in trimming between carcasses for RBY.

This study suggests that a significant G × E interaction exist in HSCW and EMA for different market end points. As previous studies have shown no significant G × E interactions between the domestic and export market endpoints, it can be assumed the differences observed in this study are due to differences in sex.

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