BREED DIFFERENCES AND GENETIC PARAMETERS FOR FAT TRAITS OF CROSSBRED CATTLE

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SUMMARY
Sires representing seven diverse breeds were mated to Hereford cows over four years and the progeny slaughtered. Highly marbled Jersey and Wagyu crossbred cattle had softer fat (6% lower melting point) than the other breeds. The Angus crosses marbled like Jersey and Wagyu, but had harder fat similar to the very lean Belgian Blue. Hereford, South Devon and Limousin crosses had harder fat than Angus crosses. The South Devon had similar marbling to the Hereford (moderate), but with much less P8 fat (similar to Limousin). Heritabilities were low (e.g. marbling 18%) to moderate (e.g. carcass weight 36%) for the various carcass traits measured.
Keywords: beef, crossbreeding, fat content, fat composition.

INTRODUCTION
Marbling is currently an important determinant of carcass value for some markets (e.g. Australian beef destined for Japan). The melting point of fat is a reflection of the fatty acid composition and hence, affects flavour as well as the ease of trimming the carcass. A lower melting point reflects a greater level of unsaturation (desirable) (Gurr and Harwood 1991). Significant sire-breed differences in melting point of fat in steers have been reported (Perry *et al.* 1998). However, genetic and phenotypic correlations between marbling, melting point, and fatty acid composition in beef cattle have not been reported. The objective of this study was to examine breed differences and estimate the genetic parameters for fat traits in beef. The results herein represent the complete data set for selected fat traits from the Australian "Southern Crossbreeding Project".

METHODS
Animals and management. The "Southern Crossbreeding Project" was conducted at Struan Research Centre, Naracoorte, South Australia and various commercial feedlots. The aim of the project was to characterise between and within-breed genetic variation for production, carcass and meat quality traits. An early description of the project was reported by Rutley *et al.* (1995) and preliminary results to those herein were reported by Malau-Aduli *et al.* (2000). The fat extraction methods, melting point measurement (slip-point of subcutaneous fat) and calculation of intramuscular fat content (chemical extraction) were as described in Malau-Aduli *et al.* (2000).

Mature Hereford cows (766) were mated to semen from 97 sires from seven breeds resulting in 1215 calves born over 4 years (1994-97). Sires were generally, although not always, only used in one year whereas it was common for dams to be used for 3-4 years. All cohorts were grain finished except the

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1997-drop steers that, after a good season in 1998, reached marketable weights (majority steers hot standard carcass weight, HSCW > 300kg, heifers >200kg) without requiring grain finishing. Calves were slaughtered at various export-licensed abattoirs throughout south-eastern Australia. They were assessed for HSCW based on a standard level of trimming (AUSMEAT® 1990), fat depth over the rump at the P8 position, fat colour (FCS) at the site of quartering (generally 10-11th rib), and various other traits not included in this paper. Samples (M. longisimus dorsi) were taken from the quartering site for determination of intramuscular fat content (IMF) and melting point of the fat (MP).

Statistical analyses. Data were analysed using ASREML (Gilmour *et al.* 2000). All traits (Table 1) were analysed with a univariate animal model containing fixed effects of cohort (8 categories of year and sex: 1994-drop heifers to 1997-drop steers), management group (4-6 groups within each cohort resulting in a total of 30 levels describing pre- and post-weaning groups), age of calf as birth month (March or April), and sire breed (7 levels). Two-way interactions were generally not significant (P>0.05) and were not included. Intramuscular fat content and P8 fat depth were transformed with a natural logarithm because of lack of homogeneity of variance. Least squares means were back transformed by ASREML. The significance of sire breed was effectively tested against sire as outlined by Gilmour *et al*. (2000, p 137). Bivariate animal models with the same fixed effects were used for estimation of phenotypic, genetic and environmental correlations.

RESULTS

Environmental effects. Cohort differences were large (P<0.001) for all traits due to rainfall affecting pasture availability, age of entry into feedlot and time on feed. The other large cohort effect was on fat colour with all the feedlot finished carcasses much lighter in colour (average 0.2 = mostly zero scores) than the pasture finished 1997-drop steers (3.0±0.1). The 1996-drop steers had the highest intra-muscular fat (6.9±0.3%) and the 1995 and 1996-drop heifers had the lowest, presumably because they were slaughtered so young (15 months). Management group effects were generally low or not significant. Differences between early (March) and late (April) born calves were small for HSCW (3.5kg) and there was no difference in fatness or fat colour. However, there were highly significant differences in fatty acid composition (unpublished) such that March born calves had fat with a 0.5ºC lower melting point than the April born calves.

Table 1. Description of traits and heritability estimates

Trait and acronym	Mean	Min.	Max.	Phen. SD[a]	Herit. (%)
Carcass weight - HSCW (kg)	272.4	120.2	461.0	26.3	36±8
Fat depth - P8 (mm) [b]	12.3	2.0	36.0	1.4	26±7
Fat colour - FC (score)	0.5	0	6	0.6	33±8
Intramuscular fat - IMF (%)[b]	4.5	1.0	16.1	1.4	18±7
Fat melting point - MP (ºC)	39.1	30.0	50.0	2.8	28±8

[a] Phenotypic standard deviation.
[b] Log transformation used for analysis.

Genetic effects. Sire breed effects were significant (Table 2) for all traits. There were four heavy breeds (Belgian Blue, South Devon, Angus, and Limousin) that averaged 6% heavier than the

Hereford (the only purebred), then Wagyu (9% lighter than Hereford) and Jersey (12% lighter than Hereford). The Angus had by far the highest subcutaneous fat depth (19% more than Hereford and Wagyu), with Jersey being 11% lower, followed by South Devon and Limousin (18% lower), and Belgian Blue being the lowest (33% lower). Jersey crosses had fat which was more yellow (1.0) than the other breeds (around 0.5). Jersey, Wagyu and Angus had 25% more (Table 2) intra-muscular fat than Hereford and South Devon, with Limousin and Belgian Blue the lowest (18% less than Hereford). The Jersey and Wagyu had higher marbling and softer fat (6% lower melting point) than the other breeds (Table 2). The Angus was the most highly marbled like Jersey and Wagyu, but had moderately hard fat similar to the Belgian Blue. Hereford, South Devon and Limousin had hard fat. The South Devon had similar marbling to the Hereford (moderate) with much less P8 fat (like Limousin).

Table 2. Least squares means for sire breed

Sire breed	HSCW (kg)	P8 (mm)	FCS (score)	IMF (%)	MP (ºC)
Jersey	236±3	10.7±0.4	1.0±0.1	4.8±0.2	37.1±0.3
Wagyu	244±3	11.8±0.4	0.5±0.1	4.5±0.1	37.8±0.3
Angus	283±3	14.3±0.6	0.5±0.1	4.6±0.2	39.4±0.4
Hereford	268±4	12.0±0.6	0.4±0.1	3.7±0.2	40.0±0.4
South Devon	284±3	9.8±0.4	0.5±0.1	3.8±0.1	40.3±0.3
Limousin	278±3	9.9±0.4	0.4±0.1	3.1±0.1	40.2±0.3
Belgian Blue	289±3	8.0±0.3	0.6±0.1	3.0±0.1	39.3±0.3

Carcass weight and fat colour were the most highly heritable traits (36 and 33% respectively), followed by fat depth and fat melting point (Table 1). Marbling (IMF) was the least heritable trait (18%). The genetic correlations calculated from 1215 calves from 97 sires had high standard errors (average 0.2) and were not significantly different from zero (Table 3). The strongest genetic correlations were between carcass weight and melting point (0.34), and fat depth and intramuscular fat (0.36). Although not significant, many of the genetic correlations were opposite in sign to the phenotypic correlations.

Table 3. Genetic (below diagonal) and phenotypic (above diagonal) correlations

	HSCW	P8	FCS	IMF	MP
HSCW		.31±.03	.00±.03	.08±.03	-.09±.03
P8	.22±.18		-.02±.03	.15±.03	-.13±.03
FCS	-.04±.17	-.14±.19		.03±.03	-.13±.03
IMF	.00±.23	.36±.23	.00±.23		-.10±.03
MP	.34±.19	.20±.22	.16±.20	.06±.26	

DISCUSSION

Heritability for intramuscular fat content (marbling) was lower (18 vs. 49%) and for subcutaneous fat depth was higher (26 vs. 15%) than that found by Oikawa *et al.* (2000) with 1100 purebred Wagyu.

The heritability for fat depth was closer to that of Splan *et al.* (1998) with larger numbers of cattle (26%) although the heritability of marbling was still lower than their estimate. When the leaner breeds (South Devon, Limousin and Belgian Blue) were excluded from the analysis, the heritability for marbling was much higher.

This study (Table 2) is consistent with previous studies (e.g. Yang *et al.* 1999) that the Japanese Wagyu has high levels of desirable fat (moderate-high subcutaneous fat, high intra-muscular fat, low melting point). Early cattle breed comparisons (e.g. Siebert *et al.* 1996) concluded that fatty acid composition is related to maturity so that large, lean breeds (e.g. Charolais) have lower levels of mono-unsaturated fats than smaller, early maturing breeds (e.g. Angus or Hereford). In this study (Table 2), the Wagyu and Jersey had higher marbling (intra-muscular fat) and had softer fat (high mono-unsaturated) than the other crosses. However, the breed with the most subcutaneous fat (Angus) was not the smallest and had a fat composition similar to the very lean Belgian Blue.

Within breeds, the genetic correlation (Table 3) between fat depth and melting point was low (0.20). Both phenotypic and genetic correlations between intra-muscular fat and melting point were low (-0.10 and 0.06 respectively), whereas the relationship across breeds (Table 2) implied a strong, negative relationship. The finding that genetic and environmental correlations were commonly opposite in direction may help to explain conflicting conclusions about the relationship between fat colour and fatty acid composition between and within previous trials (e.g. Zhou *et al.* 1993).

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