GENETIC RELATIONSHIPS BETWEEN LAMB SURVIVAL AND MEAT TRAITS

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SUMMARY

Correlations between survival traits (expressed by the lamb) and meat traits were estimated from analyses of four years of data (2007-2010) from the Sheep CRC's Information Nucleus, with records from 20,498 lambs, up to 8,596 dams and 377 sires. Tissue depth at the GR site and eye muscle depth had positive genetic correlations with lamb survival of 0.34±0.05 and 0.17±0.07, respectively, while the genetic correlations of lamb survival with lean meat yield and shear force were unfavourable (-0.33±0.06 and 0.27±0.07, respectively). Selection programs that enhance lean meat yield and reduce tissue depth at the GR site and increase tenderness need to consider the possibility of small correlated genetic losses in lamb survival, although appropriate index selection should be able to manage this risk, as the correlations were low. Conversely, genetic increases in tissue depth at the GR site may be correlated with small improvements in lamb survival.

INTRODUCTION

As poor lamb survival is a major contributor to sheep reproductive inefficiency (Alexander 1984), renewed attention is being given to its improvement through breeding. Under Australian conditions of extensive grazing systems, survival of lambs to marking or weaning age can vary considerably and is often less than 80% of lambs born, with losses considerably higher for those born as multiples (Kleemann and Walker 2005).

Lamb survival and net reproduction rate in sheep in general may be affected by correlated changes following selection on other production and quality traits. Little information on these relationships is available; what exists more relates to relationships between growth and some carcass traits with overall ewe reproduction traits (such as the number of lambs born and weaned per ewe joined) and the component traits of fertility and litter size (Safari, Fogarty and Gilmour 2005; Safari *et al.* 2007; Safari *et al.* 2008) rather than with lamb survival expressed as a trait of the lamb. The one exception is a report of positive genetic correlations between ewe body condition scores during pregnancy and ewe rearing ability (Everett-Hincks and Cullen 2009).

The results in this paper give the first estimates of genetic correlations between lamb survival and related traits (birth weight, crown rump length, rectal temperature and time taken to bleat) and a number of meat production and quality traits under study by the Sheep CRC.

MATERIALS AND METHODS

The design of the Information Nucleus (IN) has been described in detail by Fogarty *et al.* (2007). The IN program established base flocks in late 2006 at 8 sites around Australia. Annual artificial insemination matings of the IN base ewes occurred at all 8 sites from 2007 to 2011 (except at the Trangie Research Centre in 2007). The data studied here consisted of complete records of 20,498 observations from eight flocks collected from 2007 to 2010. The records included full pedigree data back to genetic groups, sex of lamb, type of birth (single, twin or multiple), age of dam (two to eight years), sire breed (one of 18 breeds), dam breed (Merino or crossbred), birth weight, survival at weaning and birth day (day of year). The pedigree included 64,869 identities.

Records collected. The measurements/scores collected at all IN sites that are most relevant to lamb survival and reproduction traits are described by Brien *et al.* (2010) for data collected from 2007 to 2009. Only 4 lamb traits previously reported by Brien *et al.* (2010) to be correlated with lamb survival to weaning (birth weight, time taken to bleat, rectal temperature and crown rump length) have been included in this study. For meat production and quality traits recorded, see Mortimer *et al.* (2010). The number of animals, dams and sires represented in the data set for each trait and the abbreviation, units, mean and standard deviation for each trait, are given in Table 1.

Statistical Analysis. Bivariate analyses were conducted with ASREML (Gilmour *et al.* 2009) on the lamb survival and meat production and quality data from the IN collected from 2007 to 2010. Lamb survival, although a binary trait, was assumed to be distributed normally for these analyses and has been treated as a trait of the lamb. In general, the bivariate analytical models fitted to the data were those used in the analyses described by Brien *et al.* (2010) and Mortimer *et al.* (2010), except that a maternal variance term could not be included.

Table 1. Summary of the data.

Trait	Abbreviation	Animals	Dams	Sires	Mean	SD
Lamb survival to weaning	LSW	20498	8596	377	0.79	0.41
Birth weight (kg)	BWT	20084	8589	377	4.7	1.1
Time taken to bleat (s)	BLT	12931	6561	298	9.0	17.7
Rectal temperature (°C)	RT	14528	6981	299	39.1	1.1
Crown-rump length (cm)	CRL	15646	7174	300	45.7	5.0
Pre-slaughter weight (kg)	PSWT	8734	5276	364	50.5	6.6
Shear force, aged 5 days (N)	SHEARF5	5572	3713	274	26.9	9.7
Intramuscular fat (%)	IMF	5735	3815	279	4.2	1.0
Tissue depth GR site (mm)	HGRFAT	8681	5286	364	13.2	5.4
Carcass weight (kg)	HCWT	8694	5256	363	23.1	3.8
Dressing percentage (%)	DP	8608	5217	363	45.6	3.7
Carcass fat depth 5th rib (mm)	CFAT5	7585	4934	363	7.1	3.5
Eye muscle depth (mm)	CEMD	7657	4979	363	30.0	4.0
Eye muscle area (cm^2)	CEMA	7654	4979	363	14.7	2.5
Lean meat yield (%)	LMY	6147	4049	362	58.0	3.1

RESULTS

Phenotypic correlations. Phenotypic correlation estimates are shown in Table 2. Phenotypic correlations with lamb survival to weaning (LSW) are not reported as lambs must survive to slaughter age to be measured for meat traits.

BWT. All correlations were either in the low (-0.2 to -0.4 or +0.2 to +0.4) or the negligible range (-0.2 to +0.2). Of all the correlations, that with pre-slaughter weight was the highest, at 0.33. The next highest were those with carcass weight (0.26) and fat at the GR site (-0.26). Remaining correlations were below 0.15. The non-zero and positive correlations with pre-slaughter weight and carcass weight were expected, given previous estimates of similar scale for correlations between weights at birth, weaning and hogget age (Safari *et al.* 2007).

CRL, RT and BLT. All estimates were in the negligible range, largely 0.07 or closer to zero. The exceptions were correlations between CRL and HGRFAT (-0.16) and HCWT (0.17).

Table 2. Estimated phenotypic (r_P) and genetic correlations (r_g) between lamb survival to weaning, key survival indicator traits and meat traits. SE in parentheses.

Trait	LSW	BWT		CRL		RT		BLT	
	r_g	r_P	r_g	r_P	r_g	r_P	r_g	r_P	r_g
PSWT	0.12	0.33	0.50	0.02	0.41	0.02	-0.15	0.02	0.10
	(0.05)	(0.01)	(0.04)	(0.01)	(0.05)	(0.02)	(0.07)	(0.02)	(0.07)
HCWT	0.21	0.26	0.39	0.17	0.35	0.04	-0.08	0.02	0.05
	(0.07)	(0.01)	(0.04)	(0.02)	(0.05)	(0.02)	(0.07)	(0.02)	(0.07)
DP	0.22	-0.04	-0.04	-0.01	0.02	0.06	0.08	0.01	-0.06
	(0.06)	(0.01)	(0.05)	(0.02)	(0.06)	(0.02)	(0.07)	(0.02)	(0.07)
LMY	-0.33	0.14	0.38	0.07	0.24	-0.05	0.06	-0.02	-0.14
	(0.06)	(0.02)	(0.05)	(0.02)	(0.06)	(0.02)	(0.08)	(0.02)	(0.08)
HGRFAT	0.34	-0.26	-0.43	-0.16	-0.25	0.04	0.13	-0.01	-0.07
	(0.05)	(0.01)	(0.04)	(0.02)	(0.05)	(0.02)	(0.07)	(0.02)	(0.07)
CFAT5	0.00	-0.14	-0.47	-0.04	-0.18	0.02	0.09	0.02	0.13
	(0.08)	(0.01)	(0.06)	(0.02)	(0.07)	(0.02)	(0.09)	(0.02)	(0.09)
CEMD	0.17	-0.04	-0.01	-0.05	-0.09	0.02	-0.04	-0.01	0.07
	(0.07)	(0.02)	(0.06)	(0.02)	(0.07)	(0.02)	(0.08)	(0.02)	(0.08)
CEMA	0.04	0.01	0.04	-0.02	-0.03	0.03	0.02	-0.01	0.02
	(0.06)	(0.02)	(0.05)	(0.02)	(0.06)	(0.02)	(0.08)	(0.02)	(0.08)
SHEARF5	0.27	0.06	0.16	0.06	0.12	0.02	-0.06	0.02	0.13
	(0.07)	(0.02)	(0.06)	(0.02)	(0.07)	(0.02)	(0.09)	(0.02)	(0.09)
IMF	0.09	-0.10	-0.17	-0.04	-0.07	-0.01	-0.03	0.00	0.07
	(0.06)	(0.02)	(0.05)	(0.02)	(0.06)	(0.02)	(0.08)	(0.02)	(0.08)

Genetic correlations. Genetic correlation estimates are shown in Table 2.

LSW. All estimates were either in the low range or are close to zero. There were low genetic correlations with HGRFAT (0.34), LMY (-0.33), SHEARF5 (0.27), DP (0.22) and HCWT (0.21). Correlations with CEMD, PSWT, IMF, CEMA and CFAT5 were negligible or close to zero.

BWT. The correlation estimates in, or close to, the moderate range were those with PSWT (0.50), CFAT5 (-0.47), HGRFAT (-0.43), HCWT (0.39) and LMY (0.38). In the negligible range were correlations with IMF and SHEARF5. Correlations with DP, CEMD and CEMA were near zero.

CRL. The only genetic correlation in the moderate range was that with PSWT (0.43), although that with HCWT (0.35) was not much less. These positive correlations are expected, given the strong genetic correlation between CRL and BWT of 0.72 (Brien and Rutley, unpublished). HGRFAT (-0.25) and LMY (0.24) had low genetic correlations with CRL. The remaining correlations were in the negligible range, although that with CFAT5 (0.18) bordered on the low range.

RT and BLT. Correlation estimates were mostly in the negligible range and below ±0.10. The exceptions were RT with PSWT and HGRFAT (-0.15 and 0.13, respectively) and BLT with PSWT, SHEARF5, CFAT5 and LMY (0.10, 0.13, 0.13 and -0.14 respectively).

DISCUSSION

Tissue depth at the GR site (0.34, positive) and LMY (0.33, negative and unfavourable) had the strongest estimated genetic correlations with LSW of all traits analysed. The genetic correlation of CEMD with LSW, at 0.17, although significantly greater than zero, is overshadowed by the correlation with fat at the GR site and the unfavourable correlation with LMY. Thus, any selection program that increases LMY, reduces fat (particularly at the GR site) and increases meat tenderness through selection for lower shear force values will need to take account of the possibility of a genetic reduction in lamb survival. Notwithstanding, the estimated zero or near zero genetic correlations with other fat measurements, such as carcase fat depth at the 5th rib ($r_{g =}$ 0.00) and intramuscular fat ($r_{g =}$0.09) do not indicate sizeable unfavourable consequences for lamb survival if those fat depots are genetically decreased. Genetic increases in slaughter weights, carcase weights, dressing percentages and eye muscle depth, traits likely to be part of breeding objectives for dual purpose and specialised sheep meat production, should all be associated with small genetic increases in LSW.

In earlier work that did not examine lamb survival, Safari *et al.* (2008) concluded that there was no antagonism between reproduction traits and carcass and meat quality indicator traits, with potential to concurrently improve reproduction, carcass and meat quality traits in Merino sheep. Whilst in general agreement, our findings suggest that if sustained selection is practiced for increased LMY and reductions in carcase fatness and shear force, lamb survival may eventually be compromised unless some selection emphasis is dedicated to the trait via appropriately weighted index selection. Conversely, if increasing carcass fatness is used as a selection criterion to enhance reproduction rate and mothering ability (e.g. for dual purpose Merino production systems) a small genetic improvement in lamb survival may be one of the benefits.

ACKNOWLEDGEMENTS

The IN and associated research programs are supported by the Australian Government's Cooperative Research Centres Program, Meat & Livestock Australia and Australian Wool Innovation Ltd. Resources are provided at IN sites by NSW DPI, the University of New England, Vic DPI, SARDI and DAFWA. Participation by Sheep Genetics and the Sheep Genomics Program is integral. Development and maintenance of the IN database is supported by AGBU.

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