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DOES PHENOTYPIC SELECTION FOR FLEECE WEIGHT REDUCE LAMB SURVIVAL?

P.G. Refshauge[1,3], S. Hatcher[2], G.N. Hinch[3], D.L. Hopkins[1] and S. Nieslen[2]

[1] New South Wales Dept. Primary Industries, Cowra, NSW, 2794
[2] New South Wales Dept. Primary Industries, Orange, NSW, 2800
[3] University of New England, School of Rural Science and Agriculture, Armidale, NSW, 2351

SUMMARY
A two year field experiment studied the impact of phenotypic selection for clean fleece weight (CFW) on 'whole ewe' performance using highly fecund medium wool Merinos stocked at either 10 or 15dse/ha. Post-mortem autopsy was undertaken on all lambs found dead (25%) during lambing in each year. Of those lambs with stomachs present for post-mortem, 92% had not fed. Birthweight and birth type significantly affected post-natal mortality and dystocia was responsible for 61% of all deaths. Fat score at mid-pregnancy was significantly and positively associated with post-natal mortality. Fat score in late pregnancy had a significant negative relationship with birthweight. CFW phenotype did not affect fat score at mid-pregnancy or post-natal mortality ($P = 0.059$).

INTRODUCTION
Selection for high fleece weight (FW) has been associated with decreased metabolic energy status and reduced fatness (Adams *et al.* 2006) and the relationship between fatness and reproduction implies CFW may reduce reproduction (Cronje and Adams 2001). A negative genetic correlation between FW and the number of lambs weaned per ewe lambing has been reported as -0.10 (Safari *et al.* 2005) but the phenotypic correlation was not presented in that study. In South African Merino lines, Cloete *et al.* (2004) reported no genetic or phenotypic correlation between the number of lambs weaned and FW (-0.01). More recently Hatcher and Atkins (2007) have shown that phenotypic selection for high CFW reduces progeny survival to weaning by 4% compared to low CFW ewes.

Across breeds most reproductive wastage in Australian flocks occurs at lambing (Kleemann and Walker 2005), with twin-born lambs most likely to die (Holst *et al.* 1986). The most common cause of post-natal mortality is the starvation, mismothering and exposure complex, which has been reported to claim on average 58% (Marchant 2004). However, dystocia has been reported to cause up to 66% of mortalities (Holst *et al.* 2002), depending on flock fecundity, genetic history and probably the more important factors of birth type and birthweight (Hall *et al.* 1995). Birth type accounts for most deaths through losses of low birthweight twin lambs and is correlated to birthweight, which has a very strong correlation to mortality (Atkins 1980). Given phenotypic selection for high CFW reduces progeny survival to weaning, our hypothesis is that it will also increase post-natal mortality.

MATERIALS AND METHODS
Data were analysed from 950 lambs born at Cowra during a two year field experiment evaluating the effect of phenotypic CFW and bodyweight (BWT) traits on dam performance. All dams were Haddon Rig Merinos, a bloodline taken from the Trangie QPLU$ project (Taylor and Atkins 1997). Adult dams (5 to 8 years of age) were selected into the project on the basis of their hogget CFW and BWT (high = H or low = L) standardised deviations and allocated into one of four phenotypes HH, HL, LH and LL using a revolving pattern of allocation (Hatcher *et al.* 2004).

The dams were joined in single-sire groups of 23-30 ewes, to Merino sires of the same phenotype, for 5 weeks commencing mid-March in 2005 and 2006. The 12 sires were selected by the same phenotypic selection and were used with three sires per phenotype group (HH, HL, LH and LL). At day 90 gestation (MP), all ewes were fat scored (White and Holst 2006) and pregnancy tested using a linear array (Toshiba SAL 32B) portable real-time ultrasound machine. During pregnancy dams (*Av.* liveweight 62.3 kg; S.D. ±6.1 kg) were randomly allocated into two replicated stocking rate treatments to impose a total nutrient intake restriction on half the ewes (Refshauge *et al.* 2006). Supplementary feed was offered as necessary at quantities that continued to impose the required nutritional differences. In late pregnancy (LP), day 140, ewes were fat scored and moved into 12 single-sire lambing paddocks. Lambing data included dam, birth type, birth weight, sex, lamb ear tags, birth date, death date, birthing assistance score, ewe behaviour and other additional comments. All dead lambs found were autopsied for the cause of post-natal mortality, according to Holst (2004).

The binary data (autopsied or not autopsied) was analysed using generalised linear mixed model methods in ASReml (Gilmour *et al.* 2002). Fixed terms in the model included birthweight, birth type, CFW, BWT, CFW x BWT, mid-pregnancy fat score, pre-lambing fat score, nutrition, year, sex and their interactions. Random terms included sire, dam, paddock, replicate, randomisation groups and their interactions. Non-significant fixed and random effects were dropped from the final models. The covariate, birthweight, was fitted using a quadratic polynomial curve. Dystocia can be explained through (1) oedema around the head and neck, or through significant cranial and central nervous system haemorrhaging, when the lamb has not metabolised its fat (2) and if it has (3). Analysis of the factors affecting dystocia used chi-square statistics and to generate sufficient power the three distinct categories of dystocia were pooled together. Causes of death, other than dystocia and starvation, were also pooled to generate sufficient scale.

RESULTS AND DISCUSSION

In 2005 the pregnancy rate (number of lambs scanned/ewe joined) was 166%, and in 2006 it was 154%. The number of lambs weaned per ewe joined was 99% in both years. The major source of reproductive wastage occurred as post-natal mortality, with 255 autopsies undertaken. The average age at death was 2.3 days (±3.5 days) and included lambs dying between 15 and 20 days post-partum. The major cause of death was dystocia, accounting for 61% of all deaths with starvation the second most important (24%). Primary predation was limited to 3%, with 57% of lamb carcases showing evidence of secondary predation. The remaining 12% of deaths were due to infection, misadventure, premature/dead *in utero*, or were undiagnosed. Interestingly, 92% of lambs that had a stomach present for post-mortem, had not fed. The factors or series of events, leading to the death of these lambs are affecting the ability to suckle. Table 1 shows the birthweight for key factors, and their effect on post-natal mortality.

Post-natal mortality declined (P<0.001) quite typically (Atkins 1980) as birthweight increased to 4 kg, however as birthweight increased beyond 6 kg, mortality increased. This suggests the ideal birthweight for these dams ranges between 4 and 6 kg. The table shows that high CFW tended to be associated with fewer mortalities (P=0.059). Hatcher and Atkins (2007) show that high CFW dams wean up to 4% fewer lambs, which suggests that lamb survival is affected elsewhere between post-partum and weaning.

Despite no significant relationship with birthweight, fat score at MP had a significant impact on mortality, with lambs from thinner ewes more likely to die. This suggests that MP fat score is not a useful indicator of birthweight but of likely mortality. In contrast, fat score at LP was related to birthweight without affecting mortality: fatter ewes at lambing had lighter lambs but their mortality was not increased. This may be partly explained by the increase in the number of ewes with lower fat scores closer to lambing, as these ewes had higher fat scores at MP. Those ewes shifting from fatter to leaner bring with them higher birthweight and better survival rates, which are already established through improved nutritional status by early-mid gestation, potentially mediating the effects observed between MP and birthweight, and LP and mortality. The relationship between nutrition or nutritional indicators at mid-pregnancy and lambing do not always impact on birthweight (Dove *et al.* 1994).

Table 1. Predicted means for traits affecting birthweight (±s.e.) and post-natal mortality

	Birthweight (kg)	P	Post natal mortality	P
Birth type				
Single	5.55 ± 0.09c	0.001	0.09 ± 0.03a	0.001
Twin	4.51 ± 0.07b		0.21 ± 0.03b	
Triplet	3.72 ± 0.14a		0.27 ± 0.07b	
Year 2005	4.49 ± 0.08	0.003	0.15 ± 0.03	0.008
2006	4.69 ± 0.08		0.20 ± 0.04	
CFW H	4.63 ± 0.09	n.s.	0.16 ± 0.03	0.059
L	4.55 ± 0.09		0.19 ± 0.04	
Fat score MP 1	4.59 ± 0.10	n.s.	0.26 ± 0.05d	0.003
2	4.59 ± 0.08		0.19 ± 0.04c	
3	4.59 ± 0.08		0.14 ± 0.03b	
4	4.59 ± 0.12		0.10 ± 0.03a	
Fat score LP 1	4.70 ± 0.09d	0.024	0.19 ± 0.04	n.s.
2	4.59 ± 0.07c		0.17 ± 0.03	
3	4.48 ± 0.09b		0.16 ± 0.04	
4	4.36 ± 0.12a		0.15 ± 0.04	
Sex M	4.71 ± 0.08	0.001	0.20 ± 0.04	n.s.
F	4.46 ± 0.08		0.15 ± 0.03	
BWT H	4.66 ± 0.10	n.s.	0.17 ± 0.04	n.s.
L	4.50 ± 0.10		0.18 ± 0.04	
Nutrition H	4.62 ± 0.10	n.s.	0.19 ± 0.04	n.s.
L	4.55 ± 0.10		0.16 ± 0.04	

Rankings are assigned to the individual pairwise means based on least significant differences (significance level 5%); n.s. – not significant.

Chi-square analysis of the factors affecting dystocia was limited by the scale of the experiment. A minimum count of 5 is required per variable in a Chi-square analysis (Moore and McCabe 1993). The least common cause of mortality is infection, at 2.3% (Marchant 2004) and to achieve a count of 5 deaths from infection, it is clear that a very large scale experiment would be required, with over 200 autopsies per variable. While not significant, the effects of sex (*P*<0.10) and nutrition (*P*<0.15) were in the expected direction. More male lambs suffered from dystocia than females and fewer males died from starvation, while fewer lambs were lost whose dams were at higher nutrition. Year had a large effect on causes of death other than starvation (*P*<0.005). An important observation was that birth type had no effect on category of death, meaning dystocia and starvation affected singleton lambs at similar rates as twins and multiples. CFW also had no relationship with death category.

CONCLUSIONS

In this study, phenotypic selection for CFW had no significant effect on post-natal lamb mortality. There was also no significant relationship between CFW and fat score at MP or LP. The apparent lack of association between fat score at MP on birthweight and between fat score at LP on mortality warrants some scrutiny. While fat score at MP affected mortality without affecting birthweight, fat score at LP influenced birthweight and not mortality. This may be associated with the capacity of fatter ewes to buffer foetal growth in late pregnancy. Further investigation is required to explain the relationships between fatness and mortality.

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