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ADULT MERINO EWES CAN BE BRED FOR LIVE WEIGHT CHANGE TO BE MORE TOLERANT TO CLIMATE CHANGE

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SUMMARY

Climate change is going to complicate sheep management in Mediterranean climates due to increased variation in the supply of pasture and crop stubbles for grazing during summer and autumn. Farmers will rely more on providing supplementary feed which is expensive. Therefore liveweight loss during periods of low nutrition and subsequent liveweight gain are likely to be economically important traits.

We estimated the genetic parameters for liveweight loss and liveweight gain on 2700 fully pedigreed 2 to 4 years old Merino ewes. When data for ewes from all ages was analysed together with age fitted as a fixed effect, liveweight gain had a heritability of 0.18 whilst liveweight loss had a heritability of 0.06. Loss and gain also had a moderate negative genetic correlation, showing that high weight loss was related to high weight gain. When liveweight change is analysed to be a different trait at each age using a multivariate model, heritability for live weight gain was 0.37 for ewes aged 2 years and 0.20 for ewes aged 3 and 4 years. Heritability for live weight loss was around 0.15 for all ages. These results suggest that liveweight change could be included in breeding programs to breed adult Merino ewes that are more tolerant to variation in feed supply.

INTRODUCTION

Most Australian sheep are produced in southern Australia. These regions are expected to get drier and the rainfall patterns more variable and less winter dominant (IPCC 2007). These changes will make managing sheep in Mediterranean regions more difficult as the length of the annual periods of drought during summer and autumn will be more severe and harder to predict. Ewes generally lose liveweight during summer and autumn and then regain weight during late winter and spring (Adams and Briegel 1998). Many Merino ewes in these areas are also pregnant or lactating during summer and autumn which amplifies the mismatch between feed supply and demand (Croker *et al*. 2009). The resulting negative energy balance impacts on reproductive and maternal performance of ewes and the survival of lambs (Oldham *et al.* 2011). Farmers can overcome the deficit in paddock feed by providing supplements but this represents a major variable cost and impacts on whole farm profit (Young *et al.* 2011a).

A possible long-term solution is to breed sheep that can maintain liveweight during times of feed shortage and therefore are more resilient to variation in feed supply. There is limited knowledge about genetic parameters for, or the potential of liveweight change in breeding programs for adaptability to feed shortage in Merino sheep. Rauw *et al.* (2010) found a heritability of 0.29 for live weight loss in pure Merino and Merino cross ewes aged 2 to 7 years grazing in the Nevada desert. However, they did not give an indication of how liveweight changes differed between periods of low nutrition and high nutrition and did not investigate liveweight change at different ages. In this paper we estimate genetic parameters for liveweight change during periods of low nutrition and high nutrition and compare these at different ages.

MATERIALS AND METHODS

Animals and their management. We used liveweight information from fully pedigreed adult ewes from the Merino Resource flocks of the Department of Agriculture and Food Western Australia at Katanning (33°41´S, 117°35´E). We used information from 1999 to 2005. The ewes lambed each year in July and further information about how the flock was managed are described by Greeff and Cox (2006).

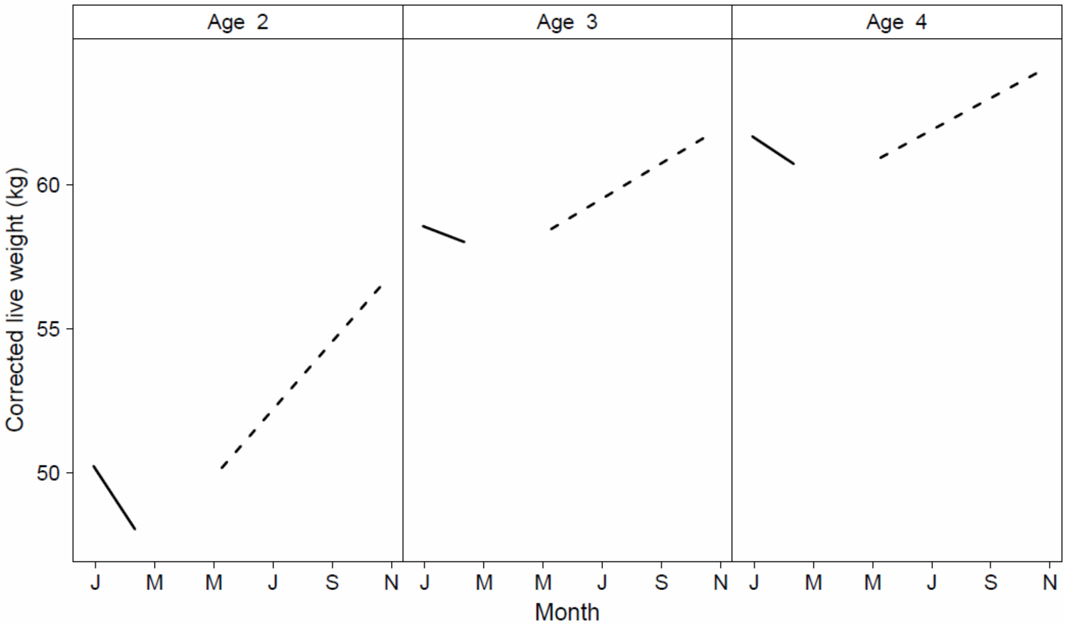

Figure 1 Average ewe liveweights and weight gain and loss corrected for wool and conceptus plotted against days from the start of the year. Liveweights are corrected for fixed effects. Full line is weight loss and dashed line is weight gain.

Liveweight data. The ewes were weighed 4 times during the year and the average dates for each weight were: pre joining (PRJN; 13th January), post joining (PSJN; 24th February), pre lambing (PRLB; 23rd May) and weaning (WEAN; 2nd October) (Figure 1). We corrected liveweights for wool weight by estimating wool growth from shearing to the day the weight was measured. These estimates did not consider fluctuations in wool growth due to nutrition, pregnancy or lactation. Conceptus weight was estimated using equations from the GRAZPLAN model (Freer *et al*. 1997) and subtracted from PSJN and PRLB. These estimates of conceptus weight used the actual birth weight of the lambs from each of the ewes. There were 2700 ewes from 217 sires in the analysis with on average 1.8 years of information each.

Liveweight traits. We defined a liveweight loss trait, loss = PSJN – PRJN, and a liveweight gain trait, gain = WEAN – PRLB (table 1). We also defined liveweight loss and weight gain as a percentage of initial weight, loss% = (PSJN-PRJN)/PRJN and gain% = (WEAN – PRLB)/PRLB, similar to the traits investigated by Rauw *et al.* (2010). The average length of the liveweight loss period was 42 days, while liveweight gain period was assessed over 193 days.

Table 1 Number of animals (*n*) used in each age group, average loss and gain and standard deviation of loss and gain.

Age group	*n*	Average loss (kg)	SD loss (kg)	Average gain (kg)	SD gain (kg)
Age 2	1980	-2.19	2.73	6.37	7.26
Age 3	1650	-0.57	3.94	3.33	7.26
Age 4	1210	-0.97	3.77	3.02	7.47
All ages	4840	-1.35	3.51	4.57	7.48

Genetic analysis Variance components were estimated using ASReml (Gilmour *et al.* 2006). We included fixed effects for year (1999-2005), number of lambs born (0-2) and reared (0-2) by each ewe in the year of liveweight measurement, and number of lambs born (0-2) and reared (0-2) in the year before the liveweight measurements.

We did an univariate analysis of loss, loss%, gain and gain% with all animals from all ages grouped together with age fitted as a fixed effect (2-4). Variance components were estimated for additive genetic effects, maternal effects, permanent environmental effects and the random residual variance.

We then did a multivariate analyses for gain and loss treating each age as a different trait. Using gain as an example, we analysed gain at age 2, age 3 and age 4 together in a multivariate analyses. A multivariate analysis was used as it considers the covariance between each age, correcting for the fact that some animals have repeated records across ages.

RESULTS

The liveweight gain traits are more heritable than the liveweight loss traits at all age groups (table 2 and table 3). There were also strong positive genetic and phenotypic correlations between liveweight gain and gain% as well as liveweight loss and loss %. There are also moderate genetic correlations between liveweight loss and gain traits.

Weight gain is genetically a very similar trait between age 3 and age 4 (r_g=0.88 ± 0.15) but quite different between age 2 and ages three (r_g = 0.47± 0.17) and four (r_g = 0.31±0.17). Correlations between ages were much lower for the loss traits compared to gain traits.

Table 2 Heritabilities (on the diagonal; ± s.e. in parentheses), genetic (above diagonal) and phenotypic (below diagonal) correlations for loss and gain traits estimated for all age groups combined by including age as a fixed effect in the model.

All ages	Loss	Loss%	Gain	Gain%
Loss	**0.06 (0.02)**	0.97 (0.00)	-0.23 (0.11)	-0.21 (0.11)
Loss%	0.98 (0.00)	**0.07 (0.02)**	-0.24 (0.11)	-0.26 (0.11)
Gain	-0.04 (0.02)	-0.04 (0.02)	**0.18 (0.02)**	0.96 (0.00)
Gain%	-0.04 (0.02)	-0.05 (0.02)	0.94 (0.00)	**0.21 (0.02)**

Table 3 Heritabilities (on the diagonal; ± s.e. in parentheses), genetic (above diagonal;) and phenotypic (below diagonal) correlations for loss and gain traits in each age group.

	Age 2		Age3		Age4	
	Loss	Gain	Loss	Gain	Loss	Gain
Loss	**0.14 (0.04)**	-0.11 (0.23)	**0.16 (0.05)**	-0.36 (0.18)	**0.14 (0.06)**	0.12 (0.30)
Gain	0.04 (0.04)	**0.37 (0.05)**	-0.04 (0.03)	**0.21 (0.05)**	-0.09 (0.03)	**0.22 (0.05)**

DISCUSSION

Our analysis indicates that it is feasible to breed adult Merino ewes that will lose less liveweight during periods of low nutrition or gain more liveweight during periods of high nutrition. This means that sheep that lose less weight during periods of low nutrition and gain more weight during periods of high nutrition are more tolerant against variation in feed supply. It will be important to understand why some sheep lose less weight or gain more weight. If sheep lose less weight because they have increased capacity to consume low quality feed through the summer or lower energy requirement for maintenance then liveweight loss will be of high economic importance (Young *et al*. 2011b) and contribute to less risky sheep management.

Additionally, gain and loss have a moderate negative genetic correlation which means that some genes are responsible for both traits. Therefore selecting ewes that lose more weight during summer and autumn will also gain more weight during spring. This implies that live weight change over the whole year is under genetic control and some genes contribute to live weight change as a complete trait, not just for weight gain and loss.

The moderate to high genetic correlations between ages 2, 3 and 4 suggest that gain could be selected for at an early age. Alternatively, the low genetic correlations between traits at age 2, 3 and 4 years for weight loss suggest that each age should be treated as a different trait in a breeding program, and early selection will be inefficient. These low correlations may also be because the loss trait is measured over 42 days compared to growth which was measured over 193. These differences are reflected in the higher variance for gain compared to loss. Additionally, any measurement errors in the weights recorded for the loss trait will impact on the variance structure of loss as the weights were recorded so close to each other.

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