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Genetically, Merino ewes that lose less live weight during joining have a higher chance of having lambs but the total weight of the born lambs is not affected

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Abstract

Sheep in many areas of Australia and New Zealand experience periods of variable feed supply. Merino sheep can be bred to be more resilient to this varying feed supply. Resilient sheep lose less live weight when grazing poor quality pasture. However, we do not know if breeding for live weight change genetically affects reproduction. To estimate genetic correlations between live weight change and reproduction we used information from 6,870 fully pedigreed Merino ewes aged two- to four-years-old. Liveweight change was measured during joining (42 days) on low quality pasture and during lactation (130 days) on high quality pasture. Reproduction traits were total weight of lambs born and weaned and binary traits of whether or not a ewe gave birth to, or weaned, a lamb. Genetic correlations between live weight change and reproduction within age were estimated. There were moderate to high genetic correlations between live weight loss during joining and the chance of having and weaning a lamb. All other correlations were low. Therefore, change in live weight during joining affects the chance of having a lamb but not the weight of those lambs.

Keywords: ewe live weight change; joining; number lambs born; lamb birth weight

Introduction

Sheep in Australia and New Zealand are often farmed in regions that are expected to get drier and the rainfall patterns more variable and less winter dominant (IPCC 2007). These changes will make managing sheep in these regions more difficult as the length of the annual periods of drought during summer and autumn will be harder to predict. Adult sheep will have to endure longer periods of negative energy balance more often, and this will affect their performance in those years. In Mediterranean regions of Australia ewes generally lose live weight during summer and autumn and then regain live weight during late winter and spring (Adams & Briegel 1998). Many ewes in these areas are joined in spring for an autumn lambing. They are thus also pregnant or lactating during summer and autumn amplifying the mismatch between feed supply and demand (Croker et al. 2009). The resulting negative energy balance has adverse impacts on reproductive and maternal performance of ewes and the survival of lambs to weaning (Oldham et al. 2011).

One solution is to breed Merino ewes that lose less live weight when paddock feed supply is low, or gain more live weight when paddock feed supply is high (Rose et al. 2011). However, the implication of breeding for live weight change on reproduction traits is unknown.

Reproduction has a high relative economic value in sheep breeding programs (Conington et al. 2004; Byrne et al. 2010) so it is important to understand the genetic correlations between live weight change and reproduction traits. Borg et al. (2009) found that number of lambs born had a high positive genetic correlation with the degree of live weight loss during late lactation. This was for Targhee ewes grazing on rangelands in the United States. However, the genetic correlation between live weight change during joining in Australian environments and reproductive performance of Merino ewes is not known. The aim of this study was to estimate genetic correlations between live weight change of Merino ewes during joining and lactation with the total number and weight of lambs born and weaned and the probability of having and weaning a lamb.

Materials and methods

Information collected from 6,870 fully pedigreed adult ewes sired by 700 rams in the Merino Resource flocks of the Department of Agriculture and Food Western Australia at Katanning (33°41´S, 117°35´E, 310 m above sea level) was used. Katanning is in the Mediterranean climate region with a period of no pasture growth during summer and autumn. All ewes were managed on one farm under normal commercial conditions and fed grain and hay supplements during summer and autumn. Lambing was in July and ewes were shorn in October. More information about how the flock was managed can be found in Greeff & Cox (2006).

Live weight change

Live weights of ewes were measured between 2000 and 2004 treating live weight at each age as a different trait for ~1,900 two-year-old, ~1,500 three-year-old ewes and ~1,100 four-year-old ewes (Rose et al. 2011). The ewes were weighed four times during the year and the average dates for each live weight were: start of joining (WT1; 13 January), post joining (WT2; 24 February), pre lambing (WT3;

Table 1 Measured traits, number of observations, unit of measurement, mean value, phenotypic variance and heritability (standard error) of each trait used in the analysis. WT1 = Live weight pre joining; WT2 = Live weight post joining; WT3 = Live weight pre lambing; WT4 = Live weight at weaning; TBW = Total birth weight of lambs per ewe, TWW = Total weight lamb weaned per ewe; LBORN = Binomial trait if a ewe gave birth to a lamb at that age or did not lamb and LWEAN = Binomial trait if a ewe weaned a lamb at that age or did not wean a lamb.

Trait	Age	Number of observations	Unit of measurement	Mean	Phenotypic variance	Heritability
WT1	2	1,980	kg	50.2	28.4	0.71 (0.05)
WT1	3	1,650	kg	58.6	38.8	0.44 (0.08)
WT1	4	1,210	kg	61.8	43.6	0.48 (0.12)
WT2	2	1,980	kg	48.1	26.0	0.72 (0.06)
WT2	3	1,650	kg	58.1	34.2	0.60 (0.08)
WT2	4	1,210	kg	60.8	33.8	0.58 (0.11)
WT3	2	2,080	kg	50.2	28.6	0.74 (0.05)
WT3	3	1,640	kg	58.4	34.0	0.60 (0.08)
WT3	4	1,220	kg	60.9	36.1	0.46 (0.11)
WT4	2	2,060	kg	56.5	42.0	0.56 (0.06)
WT4	3	1,630	kg	62.0	52.7	0.50 (0.08)
WT4	4	1,200	kg	64.0	54.9	0.50 (0.12)
TBW	2	4,670	kg	4.74	0.62	0.21 (0.03)
TBW	3	4,600	kg	4.86	0.77	0.26 (0.03)
TBW	4	3,340	kg	4.95	0.79	0.21 (0.03)
TBW	5	2,970	kg	4.88	0.70	0.25 (0.03)
TWW	2	4,080	kg	26.2	27.6	0.22 (0.03)
TWW	3	4,060	kg	26.6	32.4	0.21 (0.03)
TWW	4	3,260	kg	26.6	36.7	0.25 (0.03)
LBORN	2	5,340	1/0	0.87[1]	1.43[2]	0.30 (0.06)
LBORN	3	4,910	1/0	0.94[1]	1.25[2]	0.20 (0.05)
LBORN	4	3,600	1/0	0.93[1]	1.26[2]	0.21 (0.12)
LBORN	5	3,120	1/0	0.95[1]	1.05[2]	0.05 (0.08)
LWEAN	2	5,380	1/0	0.75[1]	1.18[2]	0.10 (0.27)
LWEAN	3	4,900	1/0	0.82[1]	1.10[2]	0.09 (0.10)
LWEAN	4	3,910	1/0	0.83[1]	1.09[2]	0.08 (0.23)

[1]Mean for LBORN and LWEAN are frequencies for the number of ewes that gave birth to or weaned lambs.
[2]Phenotypic variance above 1 because the LOGIT link function sets the residual variance to 1.

23 May) and weaning (WT4; 2 October). Live weights corrected for wool weight were calculated by estimating wool growth from shearing to the day the live weight was measured. Conceptus weight was estimated using equations from the GRAZPLAN model (Freer et al. 1997) and subtracted from WT2 and WT3.

Four live weights were used to estimate two periods of live weight change, firstly live weight change (JOINCH) over the 42 days between WT1 and WT2 during joining. During this time ewes on average lost live weight. Secondly, live weight change (LACTCH) over the 131 day period between WT3 and WT4 during lactation. During this period ewes on average gained live weight. Variance components of these live weight changes were calculated by estimating the covariance between both live weight points.

Reproduction data

We compared JOINCH and LACTCH with the reproductive performance measured between 1984 and 2004 at the same age for Age 2 (Parity 1), Age 3 (Parity 2) and Age 4 (Parity 3) for ~5,300 two-year-old ewes, ~4,900 three-year-old ewes and ~3,600 four-year-old ewes. Live weight change and reproductive performance were compared within ewe age groups. Total weight of live lambs born to a ewe (TBW) and total weight of lambs that ewes weaned (TWW) in each ewe age group were used. The average litter size was 0.74 for two-year-old ewes, 1.01 for three-year-old ewes and 1.06 for four-year-old ewes. Also estimated was the correlation between live weight change during lactation (LACTCH) with TBW the following year (TBW+1) to see if there was a carryover effect of live weight change on reproduction.

Table 2 Genetic correlations between liveweight change and reproduction traits ± standard errors. JOINCH = Liveweight change during early pregnancy; LACTCH= Liveweight change during lactation; TBW = Total birth weight of lambs per ewe; TWW = Total weight lamb weaned per ewe; TBW +1 = Total weight lamb born per ewe in the following year. NA indicates that the model did not converge.

Trait		Age		
1	2	2	3	4
JOINCH	TBW	-0.23 ± 0.17	-0.25 ± 0.19	0.28 ± 0.24
JOINCH	TWW	-0.07 ± 0.16	0.20 ± 0.19	0.07 ± 0.26
LACTCH	TBW	-0.03 ± 0.13	-0.11 ± 0.12	NA
LACTCH	TWW	-0.13 ± 0.10	NA	0.15 ± 0.15
LACTCH	TBW+1	-0.03 ± 0.13	-0.11 ± 0.12	NA

Table 3 Genetic correlations between liveweight change and whether ewes gave birth to or weaned lambs at two, three and four years of age ± standard errors. JOINCH = Live weight change during early pregnancy; LACTCH = Live weight change during lactation; LBORN = Binomial trait if a ewe gave birth to a lamb at that age or did not lamb; LWEAN = Binomial trait if a ewe weaned a lamb at that age or did not wean a lamb; LBORN +1 = and LBORN +1 = Binomial trait if a ewe gave birth to a lamb in the following year. NA indicates that the model did not converge.

Trait		Age		
1	2	2	3	4
JOINCH	LBORN	0.55 ± 0.21	0.22 ± 0.25	0.81 ± 0.53
JOINCH	LWEAN	0.56 ± 0.23	0.58 ± 0.44	0.93 ± 0.61
LACTCH	LBORN	-0.26 ± 0.17	> 1[1]	NA
LACTCH	LWEAN	> 1[1]	NA	> 1[1]
LACTCH	LBORN+1	-0.26 ± 0.17	> 1[1]	NA

[1]Correlation value exceeded 1.

Finally, two binomial traits were included for ewes that were mated and either did (1) or did not (0) give birth to any lambs (LBORN) and either did (1) or did not (0) wean any lambs (LWEAN). Including this trait meant that the estimates of genetic variance for TBW and TWW were not biased (Urioste et al. 2007).

Genetic analysis

Variance components were estimated using ASReml (Gilmour et al. 2006). Multivariate analyses were run between the binary traits (LBORN or LWEAN), reproduction traits (TBW or TWW) and the two live weight traits used to estimate the live weight change trait at two, three and four years of age. The genetic correlations between the two reproduction traits and liveweight change were calculated using variance and covariance rules. These calculations used the covariance between each live weight point and the reproduction traits, the variance for the reproduction trait and the variance for the liveweight change trait.

Fixed effects for year (1982-2005), the age of the dam of the ewe (years) were included, if the ewes were born or reared alone or as a multiple lamb with birth date as a covariate. In the case of the live weight traits the following factors were included; number of lambs born by each ewe in the year of live weight measurement (0–2), number of lambs reared in the year of live weight measurement (0–2), number of lambs born in the year before the live weight measurements (0–2) and number of lambs weaned in the year before the live weight measurements (0–2).

Results

The phenotypic data shows ewes on average lost live weight between WT1 and WT2 at all ages (JOINCH), and gained live weight from WT2 to WT3 and WT3 to WT4 (LACTCH) (Table 1). Additionally as ewes aged they increased in weight. As ewes got older, the total weight of lambs born and weaned increased. In addition, two-year-old ewes gave birth to and weaned fewer lambs compared to ewes aged three and four years of age. The heritability of live weight was high at all ages but decreased as ewes increased in age. The heritability for the traits measured at birth and weaning were moderate.

The genetic correlations between live weight change and TBW and TWW are generally low with high standard errors (Table 2). The genetic correlations between JOINCH and the proportion of ewes that gave birth to, or weaned a lamb, following each joining opportunity was positive and moderate to high at all ages (Table 3). The standard errors were very high for these parameters, especially for older ewes, but in general the correlations indicate that ewes that lose more live weight during joining have a lower probability of giving birth to, or weaning lambs.

At two years of age, there were negative moderate correlations between LACTCH and LBORN and LBORN+1. This indicates that young ewes that give birth to lambs genetically gain less live weight during lactation and ewes that have no lambs genetically gain more weight. Ewes that gain more live weight during lactation have a lower chance of having lambs the following year.

Discussion

Ewes that lose less live weight during joining on poor quality dry pasture genetically have a higher probability of giving birth to and weaning lambs. The genetic correlations between liveweight change during joining and the probability of having a lamb ranged from 0.22 to 0.81 and the correlation with probability of weaning a lamb varied from 0.56 to 0.93 across ewe age groups. To our knowledge these correlations have not been reported in the literature before.

The genetic correlation between reproduction and liveweight change depends on the additive genetic covariance between both live weight points and reproduction. As such if one covariance is higher than the other then there will be a correlation between liveweight change and reproduction. In the case of liveweight change during joining, the correlation between live weight at the end of joining and LBORN and LWEAN is higher than live weight at the start of joining and reproduction (G Rose, Unpublished data). This means that ewes that are able to gain live weight during joining have a higher chance of giving birth to and weaning a lamb. This is important because many sheep farmers in Australia and New Zealand join their ewes during periods of low pasture availability (Pitta et al. 2005; Demmers et al. 2011; Ferguson et al. 2011). The advantage of breeding ewes able to withstand the challenge of this period of low availability of paddock feed with a minimal impact on fertility would make them easier to manage during the year and to be genetically more fertile during years when pasture growth around joining is limited.

The genetic relationships between liveweight change during joining and the number of lambs born and weaned are both consistent with that expected from the phenotypic relationship (Demmers et al. 2011). Phenotypic differences in liveweight change during joining due to improved nutrition are known to influence fertility, fecundity and the number of lambs born (Ferguson et al. 2011). It is also known that ewes that are bigger at the time of conception have bigger lambs which are more likely to survive to weaning (Oldham et al. 2011).

By contrast, the genetic correlations between liveweight change during joining or lactation and the total weight of lambs born and weaned by ewes were low. This implies that in the case of ewes which lost less weight during joining and became pregnant, there was less effect on the total weight of lambs born or weaned than on the probability of having a lamb or weaning a lamb. It has been shown that the phenotypic correlation between changes in ewe live weight during lactation and lamb growth to weaning are insignificant (Thompson et al. 2011).

All ewes in the resource flocks from where the data was sourced were grazed together during pregnancy and lactation. The advantage of breeding for ewes that lose less weight during joining could potentially be greater if the ewes were better fed during late pregnancy and lactation so that the genetic gains in the number of lambs born were not largely eroded by lower birth weights and slower growth rates to weaning of these lambs. This hypothesis could be tested by estimating the genetic correlation between weight change during joining and the number of lambs born and weaned.

In conclusion, ewes that lose less live weight during joining will have a higher chance of having a lamb but the amount of live weight these ewes lose will not genetically affect the number and or total weight of the lambs that are born. Since birth weight and number of lambs are not affected genetically by liveweight change during pregnancy, then lamb survival is unlikely to be affected. Genetic correlations do not explain causality and therefore we do not know whether liveweight change of the ewes affects the reproductive performance or vice versa. Furthermore, future research should include genetic correlations with ewe liveweight change during all of pregnancy because phenotypically liveweight change during joining is important not only for birth weight and lamb survival but also for lifetime wool production (Thompson et al. 2011).

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