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Managing the nutrition of twin-bearing ewes during pregnancy using Lifetimewool recommendations increases production of twin lambs

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Abstract. The effect on ewe and lamb production by differential management of single- and twin-bearing Merino ewes during pregnancy and lactation was examined. The hypothesis that the survival and productivity of single- and twin-born progeny is not affected by differential management of single- and twin-bearing ewes was tested. To test this hypothesis, two ewe flocks were monitored on a commercial property in the south-east of South Australia. The body condition score of one flock of ewes was managed according to Lifetimewool recommendations for southern Australian (Lifetimewool flock; $n = 464$). Lifetimewool recommendations are that body condition score should be 3.0 at mating and then allowed to decline to an average of 2.7, which is maintained until lambing. Twin- and single-bearing ewes were managed as separate mobs after pregnancy scanning to meet their energy requirements. The second flock was managed similarly to the commercial ewe flock and was representative of ewe management practices in the region (normal-practice flock; $n = 464$). At lambing, the condition score of the Lifetimewool flock was 0.7 condition scores units greater than the normal-practice flock. Ewe clean fleece weight and fibre diameter were greater in the Lifetimewool flock and their lambs had higher survival rates to weaning. Over three shearings, progeny from Lifetimewool ewe flocks produced more clean wool ($P < 0.0001$) but there was no consistent effect on fibre diameter, staple length or staple strength. Twin-born lambs from ewes managed to Lifetimewool guidelines had a similar liveweight and produced similar quantity and quality of wool to single-born lambs managed to Lifetimewool guidelines, but still suffered higher rates of mortality to weaning. This suggests that it is possible to manage ewes pregnant with twins to ensure that their surviving progeny perform at a level similar to single-born progeny managed under similar targets.

Additional keywords: lifetime ewe management, Merino, wool.

Introduction

When Merino ewes are managed as a single mob, there might be inadequate nutrition to meet the energy requirements of the twin-bearing ewes during pregnancy and lactation. This can result in production penalties of twin-born lambs compared with single-born lambs. In general, Merino lambs born as twins tend to have higher mortality (Lloyd Davies 1964; Mullaney 1969; Holst *et al*. 2002; Kleemann and Walker 2005; Oldham *et al.* 2011), are smaller and produce less wool of slightly greater fibre diameter (Brown *et al*. 1966; Mortimer and Atkins 1989; Lewer *et al*. 1992; Thompson *et al.* 2011).

Mortality of twin-born lambs is consistently higher than single-born lambs (Hinch 2009). These differences in survival between lambs from litters of different sizes are predominantly due to differences in lamb birthweight (Hinch *et al*. 1985, 1996; Kenyon *et al*. 2007). There is a curvilinear relationship between lamb birthweight and survival in Merinos, with lamb mortality being highest at both low and high birthweights (Mullaney 1969; Atkins 1980; Hatcher *et al*. 2009; Oldham *et al*. 2011). Manipulating ewe nutrition during pregnancy to increase birthweight could improve survival of twin lambs (Oldham *et al*. 2011), but may increase the mortality of single-born lambs due to an increase in dystocia (Hatcher *et al*. 2009). It is therefore likely that managing twin- and single-bearing ewes separately could increase survival of both twin- and single-born lambs.

Persistent effects of twin births on wool production in Merinos are well established, with single-born lambs producing more wool that is finer than twin-born lambs (Brown *et al*. 1966; Lax and Brown 1967; Safari *et al*. 2007; Thompson *et al*. 2011). This is due to the effect of *in utero* competition for nutrients on follicle initiation, with fewer secondary follicles

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being produced in twin-born lambs (Schinckel 1953; Jackson *et al*. 1975; Hocking Edwards *et al*. 1996), although there is some evidence that these differences in the follicle population do not persist in all Merinos (Thompson *et al*. 2007). Furthermore, nutrition of ewes during pregnancy and lactation affects wool production over the life of both single- and twin-born progeny. Improving the nutrition of Merino ewes during pregnancy and lactation increases the fleece weight and reduces the fibre diameter of their progeny's wool during their lifetime (Kelly *et al*. 2006; Thompson *et al*. 2011).

Recently, guidelines and toolkits have been produced to enable wool producers to optimise Merino ewe nutrition to increase farm profit (Behrendt and Curnow 2008; Curnow *et al*. 2011). Optimum condition score (CS) profiles that are regionally based have been developed for sheep producers in Australia (http://www.lifetimewool.com.au, verified 17 January 2011). For example, the optimum profile for a spring-lambing flock in the high-rainfall zone of south-eastern Australia is (1) to allow for moderate loss of condition from joining to the 'break of season', provided the condition can be regained before lambing on green feed and (2) to aim for CS 3 at joining. In addition, these tools recommend that ewes should be pregnancy scanned for single and twin fetuses to allow for separate management throughout late pregnancy and lactation.

However, there have been no studies published that demonstrate whether twin-bearing Merino ewes can be managed to produce progeny that have similar productivity to single-born progeny. The present study examined whether providing nutrition to meet maintenance requirements to twin-bearing ewes during pregnancy and lactation using tools available to producers will enable their offspring to perform similarly to single-born lambs. We tested the hypotheses that the survival and productivity of single- and twin-born progeny is not affected by differential management of single- and twin-bearing ewes. To test this hypothesis, one flock of ewes was managed according to regional 'norms' under direction from a regional wool-producer group and a second ewe flock was managed to Lifetimewool guidelines for the high-rainfall zone of south-eastern Australia, using tools available to producers (Curnow *et al*. 2011). In addition, twin-bearing ewes were managed separately to single-bearing ewes.

Materials and methods

Location and environmental conditions

This experiment was conducted between January 2005 and March 2008 on a commercial farm 'Cherrita' at Keilira (36°34′S, 140°6′E) situated in the south-east of South Australia, which has a typical Mediterranean environment of hot, dry summers and cold, wet winters. During the experimental period, the region was in drought with rainfall significantly below average, resulting in extremely poor pasture growth and higher levels of supplementary feeding than is considered normal.

Animal experimentation had approval from the PIRSA Animal Ethics Committee (AEC Approval Number PIRSA 27/03) and was conducted in accordance with the guidelines set out by the National Health and Medical Research Council of Australia, CSIRO and the Australian Agricultural Council (National Health and Medical Research Council 2004).

Management and measurement of ewes

Multiparous Merino ewes (3–5 years of age; n = 928) with an average CS of 3.1 were mated to Merino rams (n = 17) in January 2005 for 35 days. The ewes were managed as a single flock until it was predicted that the CS of the ewes would fall below 2.7, using Lifetimewool feed-budget tables (http://www.lifetimewool.com.au). At this time (72 days after the start of mating), ewes were randomly split into two equal-sized flocks, normal practice (NP) and Lifetimewool (LW). The ewes were pregnancy scanned 86 days after the start of mating and those that were not pregnant were removed from the experiment. Based on scanning results, the LW flock was further split into single-bearing (n = 377) and twin-bearing (n = 51) ewes. The NP flock contained 366 single-bearing and 61 twin-bearing ewes.

Management of the NP ewes during pregnancy was undertaken in consultation with a local sheep-producer group and the owners of 'Cherrita' to represent 'normal' ewe management practise in the region. Ewe management and supplementary feeding was determined by historical practices, current feed conditions and grain prices and undertaken by the commercial farmer and was identical to how the remaining commercial ewes were managed on the Cherrita. Supplementation levels of the NP ewes were ~70% of the requirements during pregnancy (Table 1) and were increased to 100% of the requirements of single-bearing ewes during lactation. LW ewes were supplemented to meet 100% of their energy requirements (Table 1). Twin-bearing LW ewes did not eat the entire supplement offered from 149 days after ram introduction.

Single-bearing LW ewes and all NP ewes were combined into a single flock and then randomly allocated to one of three paddocks for lambing at Day 145 of pregnancy. Twin-bearing LW ewes were managed as a separate flock from pregnancy scanning until weaning.

All ewes were weighed and condition scored (Jefferies 1961) at mating and weaning. A random sample of ewes (n = 100) was weighed and condition scored at the end of mating and when the ewes were split into LW and NP flocks. After pregnancy scanning, all twin-bearing ewes and 80–120 single-bearing ewes from each flock were weighed and condition scored at approximately monthly intervals until lambing and at marking. Ewes were shorn in December 2005, with 10.5 months wool growth. Midside samples of wool (~50 g) were collected before shearing. Washing yield, mean fibre diameter (FD), staple length and strength were measured in a commercial laboratory using Australian Standard methods. Greasy fleece weight (GFW) was measured at shearing.

Average CS of the flock and CS targets were used to estimate feed requirements using feed-budgeting tools developed in the Lifetimewool project (Curnow *et al*. 2011). Feed on offer (FOO) was estimated by a single observer, using pasture cuts to calibrate visual estimates (Thompson *et al*. 1994). Ewes were supplemented with lupins alone until Day 110 and then with a mix of lupin (*Lupinous albus*) and barley (*Hordeum vulgare*). Nutritive value of the supplement and some of the pasture was determined commercially (FeedTest, Hamilton, Vic., Australia). When nutritive value of the pasture was not measured, it was

Table 1. Stocking rate, feed on offer (FOO), pasture metabolisable energy (ME), supplement offered and estimated total intake for single-bearing (1) and twin-bearing (2) ewes during pregnancy and lactation managed under Lifetimewool recommendations (LW) or normal practice (NP)

Days after ram introduction are provided for pregnancy and lactation periods

Variable	Pregnancy															Lactation					
	Day 0	Day 56	Day 72		Day 86			Day 125			Day 140			Day 150		Day 164		Day 187		Day 200	
	All	All	NP	LW	NP	LW1	LW2	NP	LW1	LW2	NP	LW1	LW2	NP and LW1^{B}	LW2	NP and LW1^{B}	LW2	NP and LW1	LW2	NP and LW1	LW2
Stocking rate (ewes/ha)	51	14	14	17	14	14	5	14	14	5	14	14	5	10	25	10	25	10	3	9	3
Pasture FOO (kg DM/ha)	4020	1180	1140	930	1050	900	900	900	850	700	700	700	500	<200	<200	279	205	500	900	500	900
Pasture ME (MJ/kg DM)	6.5	6.0	6.0	6.7	6.3^{A}	6.3^{A}	6.3^{A}	6.0^{A}	6.0^{A}	6.0^{A}	6.0^{A}	6.0^{A}	6.0^{A}	6.3^{A}	6.3^{A}	7.0^{A}	7.0^{A}	7.0^{A}	11.7	9.5	9.0
Supplement offered (MJ ME/ewe.day)	0	1.4	1.4	4.2	1.4	4.2	4.2	4.4	7.9	9.8	7.5	9	12.5	8.4	12.5	6.5	11	0.0	0.0	0.0	0.0
Estimated energy intake (ME/ewe.day)	7.9	5.6	5.6	8.5	5.6	8.5	8.5	7.4	10.2	11.8	9.6	11.4	13.9	10.6	13.2	16.1	20.3	17.4	22.5	16.3	20.7
Proportion of ME requirement (%)	103	70	70	100	65	100	100	74	104	105	80	104	108	90	100	90	90	96	97	105	108

^{A}Estimated ME.
^{B}Average of three lambing paddocks.

estimated based on historical data, proportion of green matter in the pasture, growth stage and quantity (Table 1).

Progeny management and measurements

Lambs were marked in August 2005, at an average age of 50 days, and weaned in September at an average age of 100 days onto balansa clover (*Trifolium michelianum*)-based pastures. The progeny were managed as a single mob until January 2006, when they were divided into two mobs based on sex. The weaners were supplemented on dry pasture during summer with a balansa-clover hay supplement (128 g/sheep.day; metabolisable energy = 9.9 MJ/kg DM; crude protein = 16.6%) from February until there was sufficient green pasture to cease supplementary feeding in April 2006. Progeny were weighed at marking, weaning and at ~4-monthly intervals thereafter.

All progeny were shorn at 8 and 19 months of age. The ewe progeny were shorn at 30 months of age and the wethers were shorn at 28 months of age. GFWs of all available progeny were measured at shearing and midside wool samples were collected from a subsample of sheep before shearing. Sheep were weighed and condition scored at midside sampling. Two hundred midside samples (~30 g/sample) per year were measured for washing yield and FD, and 25 samples from each group were tested for staple length and staple strength.

Statistical analyses

Linear mixed models were used to analyse ewe liveweight and CS (SAS 2002–2003, SAS Institute Inc., Cary, NC, USA). The fixed terms in the model included ewe flock (LW/NP), number of fetuses (single/twin), days after ram introduction (Day) and all interactions. Ewe was included as a random effect. Day was not included as a repeated term as a random subsample of ewes was measured at each weighing date. A linear mixed model was used to analyse ewe fleece data, with ewe flock, number of fetuses and their interaction included as fixed effects.

For the progeny data, a linear mixed model was used to analyse liveweight for each sex separately. The fixed terms in the model included ewe flock (LW/NP), birth type (single/twin) and sex and all interactions. Age was included as a repeated term in the analysis of progeny liveweight. General linear modelling (SAS 2002–2003) was used to analyse ewe and lamb survival, with ewe flock and birth type included as fixed effects.

Results

Ewe production

Over pregnancy and lactation, the LW ewes were 0.3 greater than the NP ewes ($P < 0.0001$; Fig. 1). At lambing (Day 145), the LW flock was, on average, 0.7 of a CS greater than the NP flock ($P < 0.001$). The single-bearing LW ewes were 0.18 of a CS greater than the LW twin-bearing LW ewes ($P < 0.01$), which were 0.46 of a CS greater than the NP single-bearing NP ewes ($P < 0.0001$). The single-bearing NP ewes were 0.26 of a CS greater than the NP twin-bearing NP ewes ($P < 0.0001$). During lactation, there were significant differences between all ewe

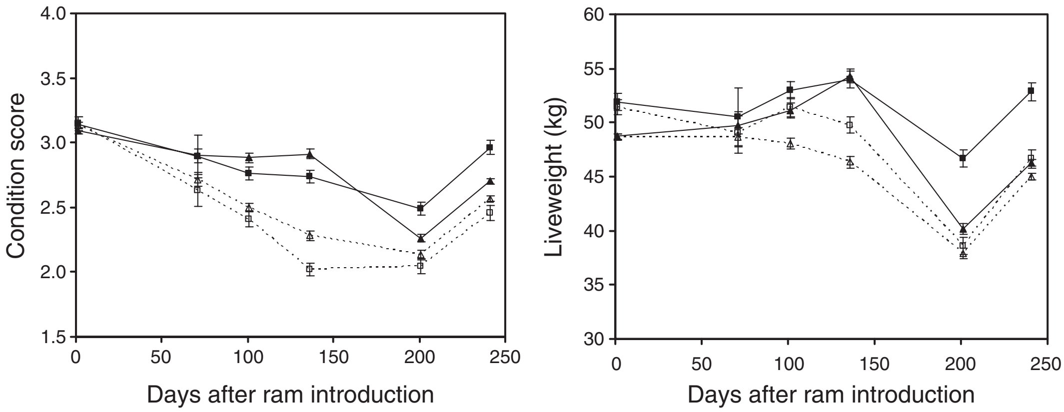

Fig. 1. Condition scores and liveweights of single-bearing (triangles) and twin-bearing (squares) ewes during pregnancy and lactation. Ewes were managed to achieve different condition scores. LW, ewes managed under Lifetimewool recommendations (closed symbols); NP, normal-practice ewes (open symbols). Values plotted are least square means with standard error bars.

flocks, with the exception that there was no difference in CS between the single- and twin-bearing NP ewes.

Overall, the LW ewes were 3.0 kg heavier than the NP ewes ($P < 0.0001$) and the single-bearing ewes were 2.8 kg lighter than the twin-bearing ewes ($P < 0.0001$; Fig. 1). There was no interaction between ewe flock and fetal number for liveweight, although there was a significant ($P < 0.0001$) interaction over time. At lambing, there was no difference in average liveweight between the single- and twin-bearing LW flocks and both were 8 kg heavier than the single-bearing NP ewes ($P < 0.0001$) and 4 kg heavier than the twin-bearing NP flock ($P < 0.0001$). During lactation the twin-bearing LW ewes were significantly ($P < 0.0001$) heavier than all other ewes.

Ewes from the LW flock produced more wool ($P < 0.001$; Table 2) that was broader ($P < 0.01$) than the NP ewes. There was no effect of fetal number on clean fleece weight (CFW) or FD. There was no effect of ewe flock or birth type on yield, staple length or staple strength and no interaction between ewe flock during pregnancy and fetal number on any of the wool measurements.

Lamb and ewe survival

There was a significant effect of ewe flock ($P < 0.001$), birth type ($P < 0.001$) and a significant interaction between flock and birth type ($P < 0.01$) on lamb survival. Lamb survival was significantly ($P < 0.001$) lower for the twin-born lambs compared with single-born lambs in the LW flock (Table 3), and the survival rate of twins in the LW flock was significantly ($P < 0.001$) lower than that of singles in the NP flock. Eleven percent more single-born lambs and 29% more twin-born lambs survived to weaning in the LW flock compared with the NP flock (Table 3). This resulted in 61 lambs weaned per 100 fetuses scanned in the NP ewes, compared with 82 lambs weaned per 100 fetuses scanned in the LW ewes.

There was a significant effect of ewe flock ($P < 0.001$), birth type ($P < 0.01$) and a significant interaction between flock and birth type ($P < 0.01$) on ewe survival. There was no difference in survival of single- and twin-bearing ewes in the LW flock, whereas twin-bearing NP ewes had a significantly lower survival rate than the other groups of ewes (Table 3).

Progeny production

Over time, lambs born to ewes managed under Lifetimewool recommendations were significantly ($P < 0.005$) heavier than lambs born to ewes managed under normal commercial conditions during pregnancy and lactation. There was no overall effect of birth type or sex on progeny liveweight. However, there was a significant ($P < 0.05$) ewe flock by birth type interaction.

At marking at 2 months of age, there was a significant effect of the ewe flock and birth type and a significant interaction between the two factors (Table 4). At this age, the twin-born lambs from LW ewes were significantly heavier than all other

Table 2. Greasy fleece weight (GFW), clean fleece weight (CFW), fibre diameter (FD), staple length (SL) and staple strength (SS) of single- and twin-bearing ewes managed under Lifetimewool (LW) or normal-management (NP) protocols during pregnancy and lactation

The values are least square means and their standard errors (in parentheses). Means followed by different letters in each column are significantly different from each other ($P = 0.05$)

Ewe attributes	GFW (kg)	CFW (kg)	FD (um)	SL (mm)	SS (N/ktex)
LW single	3.23 (0.087)a	2.25 (0.065)a	20.2 (0.31)ab	79 (1.4)ab	22.7 (2.06)ab
LW twin	3.35 (0.090)a	2.24 (0.068)a	21.0 (0.32)a	82 (1.5)a	21.9 (2.13)ab
NP single	2.94 (0.090)b	2.03 (0.068)b	19.7 (0.32)b	80 (1.5)ab	25.3 (2.13)a
NP twin	2.88 (0.087)b	1.92 (0.065)b	19.8 (0.31)b	78 (1.4)b	19.1 (2.06)b

Table 3. Lamb survival (%; no. of lambs at weaning/no. of fetuses at scanning) and ewe survival (%; no. of ewes at weaning/no. of ewes at scanning) from Lifetimewool (LW) and normal-practice (NP) ewe flocks

The values are least square means and their standard errors (in parentheses). Means followed by different upper-case letters are significantly different form each other in lamb survival, and the means followed by different lower-case letters are significantly different from each other in ewe survival ($P = 0.05$)

Ewe attribute	Lamb survival (%)		Ewe survival (%)	
	Single	Twin	Single	Twin
LW	95 (1.8)A	69 (3.5)B	99 (0.9)a	98 (2.6)ab
NP	84 (1.8)C	40 (3.4)D	95 (0.9)b	82 (2.4)c

progeny. From weaning at 3.5 months until the end of the measurement period at 33 months of age, there was no difference in liveweight between single- and twin-born progeny from the LW ewes (Table 4). Twin-born progeny from NP ewes were significantly lighter than both single- and twin-born progeny from LW ewes for the entire experiment. Furthermore, the twin-born progeny from the NP ewes weighed significantly less than single-born lambs from the NP ewes at all ages during this experiment, with the exception of the ewe progeny at their first mating at 18 months of age (Table 4).

Progeny born to LW ewes produced more wool ($P < 0.05$) over the three shearings measured in this experiment compared with progeny from NP ewes. In addition, single-born progeny had a higher CFW than twin-born progeny ($P < 0.01$), and females produced more wool than males ($P < 0.001$). There was also an interaction between ewe flock and birth type ($P < 0.05$) on progeny fleece weight.

At their first shearing, progeny from the LW ewes produced 150 g/head more CFW than progeny from the NP ewes ($P < 0.0001$), single-born progeny produced 100 g/head wool more than twin-born progeny ($P < 0.01$) and females produced 100 g/head more wool than males ($P < 0.01$). Similarly, at the second shearing, progeny from NP ewes produced 160 g/head more wool than progeny from NP ewes ($P < 0.001$), single-born progeny produced 130 g/head more wool than twin-born progeny ($P < 0.01$) and females produced 280 g/head more wool than males ($P < 0.0001$). At the third shearing, progeny from NP ewes produced 140 g/head more wool than progeny from NP ewes ($P < 0.05$), single-born progeny produced 170 g/head more wool than twin-born progeny ($P < 0.01$) and females produced 230 g/head more wool than males ($P < 0.0001$). There was no difference in CFW between single- and twin-born progeny from LW ewes and single-born progeny from NP ewes (Table 5). Twin-born progeny from NP ewes produced significantly less wool than all other progeny at their first, second and third shearing. A similar pattern occurred for GFW.

Over time, there was no effect of ewe flock on progeny FD, staple length or staple strength. Wool FD from single-born progeny was 0.22 μm finer than that from twin-born progeny ($P < 0.05$) and wool FD from males was 0.51 μm finer than that from females ($P < 0.0001$). Staples from female progeny were 10 mm longer and 5 N/ktex stronger than staples from male progeny ($P < 0.0001$). There was no effect of birth type on staple length or staple strength, nor were there any significant interactions between any of the factors on FD, staple length or staple strength. At the first shearing, there was no effect of ewe flock, birth type or sex on FD.

At the second shearing of the progeny, there was no effect of ewe flock on FD, staple length or staple strength (Table 6). Twin-born progeny produced wool that was 0.37 μm broader than wool from single-born progeny ($P < 0.01$). There was no effect of birth type on staple length or staple strength. Males produced wool that was 1.03 μm finer than females ($P < 0.0001$) and 8 mm shorter in staple length ($P < 0.0001$). Wool from females was 1.5 N/ktex stronger than wool from males ($P < 0.05$). Wool from single-born progeny from the NP flock was significantly finer than that from other progeny (Table 6). There was no significant difference in FD among single-borne LW, twin-born LW and twin-born NP progeny.

At the third shearing, the FD of the wool from twin-born progeny was 0.33 μm broader than that from single-born progeny ($P < 0.05$) and the FD of the wool from females was 0.51 μm broader than that from males ($P < 0.001$). There was no effect of ewe flock on FD, staple length or staple strength (Table 6) and no interactions between any of the factors. Females produced longer wool than males ($P < 0.0001$) and twin-born progeny produced longer wool than single-born progeny ($P < 0.05$). Staple strength of females was 10 N/ktex stronger than males ($P < 0.0001$).

Discussion

Managing ewes during pregnancy according to Lifetimewool guidelines (i.e. LW ewes) increased liveweights, survival and wool production of their progeny, compared with progeny from ewes that were managed using normal farming practices (i.e. NP

Table 4. Liveweight (kg) of single- and twin-born lambs from ewes managed under Lifetimewool recommendations (LW) or normal practice (NP) during pregnancy

The values are least square means and their standard errors (in parentheses). Means followed by different letters within sex in each column are significantly different from each other ($P = 0.05$). Only females were weighed at 18 months

Ewe attributes	Age (months) 2	3.5	6	10	14	18	21	33
LW single	11.6 (0.12)a	18.9 (0.17)a	30.5 (0.61)a	29.4 (0.22)a	32.1 (0.23)a	39.4 (0.37)ab	37.4 (0.25)a	55.6 (0.44)ab
LW twin	12.4 (0.28)b	19.1 (0.38)a	31.3 (0.57)ab	29.4 (0.51)a	32.0 (0.53)ab	40.8 (1.26)a	38.1 (0.59)a	56.6 (0.95)a
NP single	10.7 (0.14)c	18.1 (0.18)b	29.4 (0.54)b	28.8 (0.24)a	31.1 (0.24)b	38.7 (0.40)ab	36.9 (0.26)a	56.0 (0.47)a
NP twin	8.7 (0.34)d	15.5 (0.45)c	27.2 (0.68)c	26.5 (0.60)b	29.8 (0.62)c	37.4 (0.97)b	35.5 (0.64)b	53.4 (1.12)b

Table 5. Number of progeny measured (*n*), clean fleece weight and greasy fleece weight of single- and twin-born progeny from ewes managed under Lifetimewool recommendations (LW) or normal practice (NP) during pregnancy and lactation

The values are least square means and their standard errors (in parentheses). Means followed by different letters in each column are significantly different from each other ($P = 0.05$)

Ewe attributes	Clean fleece weight (kg)						Greasy fleece weight (kg)					
	n	1st shearing	*n*	2nd shearing	*n*	3rd shearing	*n*	1st shearing	*n*	2nd shearing	*n*	3rd shearing
LW single	146	1.84 (0.024)a	145	2.43 (0.031)a	143	3.39 (0.036)a	331	2.58 (0.022)a	308	3.59 (0.026)a	292	5.06 (0.035)a
LW twin	62	1.83 (0.040)a	54	2.39 (0.056)a	52	3.32 (0.066)a	62	2.57 (0.054)ab	54	3.65 (0.066)ab	56	4.99 (0.084)a
NP single	146	1.78 (0.024)a	151	2.35 (0.031)a	157	3.36 (0.035)a	287	2.49 (0.024)b	277	3.51 (0.027)b	262	5.00 (0.037)a
NP twin	46	1.59 (0.044)b	46	2.13 (0.056)b	40	3.08 (0.069)b	47	2.27 (0.059)c	46	3.28 (0.065)c	43	4.63 (0.091)b

Table 6. Fibre diameter (FD), staple length (SL) and staple strength (SS) of single- and twin-born progeny from ewes managed under Lifetimewool recommendations (LW) or normal practice (NP) during pregnancy and lactation

The values are least square means and their standard errors (in parentheses). Means followed by different letters in each column are significantly different from each other ($P = 0.05$)

Ewe attributes	*n*	Fibre diameter (μm)			Staple length (mm)		Staple strength (N/ktex)	
		1st shearing	2nd shearing	3rd shearing	2nd shearing	3rd shearing	2nd shearing	3rd shearing
LW single	146	17.7 (0.10)	17.2 (0.09)a	19.0 (0.10)	85 (1.8)	105 (1.8)ab	19 (0.8)	30 (1.6)
LW twin	62	17.9 (0.16)	17.5 (0.16)a	19.2 (0.19)	85 (1.8)	109 (1.9)a	19 (0.8)	29 (1.6)
NP single	146	17.7 (0.10)	16.9 (0.09)b	19.0 (0.10)	83 (1.8)	102 (1.8)b	19 (0.8)	29 (1.6)
NP twin	46	17.8 (0.17)	17.4 (0.16)a	19.4 (0.20)	82 (1.8)	106 (1.8)ab	19 (0.8)	27 (1.6)

ewes). In addition, differences in liveweight and wool production between twin- and single-born progeny were reduced by differential management. Overall, the null hypothesis that the survival and productivity of single- and twin-born progeny is not affected by differential management of single- and twin-bearing ewes was rejected; however, differential management did not overcome issues of lower mortality of twin-born lambs.

Progeny production

More twin lambs survived from LW ewes than from NP ewes. This indicates that lamb survival can be improved by increasing liveweight and CS of the ewe during pregnancy and lactation. However, survival of twin-born lambs from LW was significantly lower than survival of single-born lambs from both the LW and NP ewes. Therefore, differential management of twin-bearing ewes during pregnancy did not completely overcome the effect of being a twin on mortality, despite these ewes having liveweights similar to those of single-bearing ewes. Twin-bearing ewes managed under Lifetimewool guidelines had a CS 0.18 units lower than did the single-bearing LW ewes and this may have contributed to the higher lamb mortality. It has been predicted that if single- and twin-bearing ewes are managed to have a similar CS at lambing, the survival of twins would still be 20–25% lower than that for singles (Oldham *et al.* 2011), reflecting the difference observed in the current experiment.

Ewe liveweight and CS were unable to completely describe lamb survival. Twin-born progeny from LW ewes had lower survival than single-born progeny from NP ewes. This was despite the twin-bearing LW ewes being 8 kg heavier and having a CS 0.5 units higher than for the single-bearing NP ewes. The twin-born lambs from the LW ewes were significantly heavier than all other lambs at marking; however, lambs were not weighed at birth and no autopsies were performed so it is not possible to determine the cause of death in the LW twin flock.

Feeding twin-bearing Merino ewes to meet their maintenance requirements during late pregnancy eliminated the liveweight disadvantage that occurs in twin-born lambs compared with single-born lambs. When twin-bearing ewes were managed separately to single-bearing ewes, there was no difference in liveweight between single-born and twin-born lambs at any age. In contrast, when twin-and single-bearing ewes were managed together, twin-born progeny weighed significantly less than their single-born counterparts until 33 months of age. Likewise, when twin- and single-bearing ewes were managed together during pregnancy and lactation, twin-reared progeny remained lighter than single-reared progeny for at least 4 years (Thompson *et al.* 2011).

When twin- and single-bearing ewes were managed separately according to Lifetimewool guidelines, both twin-born and single-born lambs produced a similar quantity of wool at all shearings. This supports the producer guidelines that Lifetimewool production of twins will be improved by managing twin- and single-bearing ewes separately during pregnancy. When the twin- and single-bearing ewes of the NP flocks were managed together, twin-born progeny produced down to 0.3–0.4 kg less wool per shearing than the single-born progeny. This is of a similar magnitude of the effect of birth type on wool production reported by others (Lewer *et al.* 1992; Safari *et al.* 2007; Thompson *et al.* 2011).

Twin-born progeny from LW ewes produced 0.3 kg more wool than twin-born lambs from the NP flock, supporting Lifetimewool recommendations for ewe CS targets during pregnancy for twin-bearing ewes. However, single-born lambs from LW ewes produced the same amount of wool as single-born lambs from NP ewes that lost 0.7 CS units during pregnancy. Furthermore, there were inconsistent effects of ewe flock on FD, staple length and staple strength. This is in contrast to significant differences in wool production between progeny from ewes with different CS where the changes in CS between the ewes were of similar magnitude to the present study (Behrendt *et al*. 2011; Thompson *et al*. 2011). In the current experiment, the single-bearing LW ewes and the NP ewes were managed as a single flock from 145 days after ram introduction. The single-bearing LW ewes lost more liveweight and body condition between the start of lambing and marking at 200 days after ram introduction. As the ewes lambed over a 35-day period, it is possible that the liveweight loss that occurred during lambing negatively impacted on wool follicle initiation in the lambs that were born in the latter part of the lambing period, resulting in a depression of Lifetimewool production of the single-born progeny from the LW ewes.

Ewe production

Decision support tools developed for wool producers to optimise ewe management (http://www.lifetimewool.com.au, verified 17 January 2011; Curnow *et al*. 2011) were successfully used to achieve the target condition score during pregnancy of a commercial flock of single-bearing ewes. However, the twin ewes lost condition during late pregnancy and early lactation, despite being supplemented at a rate expected to maintain their condition score. In fact, the twin-bearing ewes failed to consume all of the supplement offered from 150 days after ram introduction. This demonstrates the difficulty in achieving adequate nutrition in extensive commercial conditions during late pregnancy and lactation for twin-bearing ewes. Others have suggested that it is not necessary to feed twin-bearing ewes separately from single-bearing ewes due to their ability to take advantage of supplements by eating more supplement and eating less pasture (Holst *et al*. 1996). Our results contradicted this conclusion as it was not possible to maintain twin-bearing ewe condition perinatally even with separate feeding. This is possibly due to the inability for twin-bearing ewes to be able to consume enough feed to meet their energy requirements in late pregnancy and lactation.

There was a 0.25-kg difference in ewe CFW between LW and NP ewe flocks, which was less than that reported for the national paddock-scale analysis (0.67 kg difference for 1 CS; Behrendt *et al*. 2011) and the plot-scale analysis (0.61 kg difference for 10 kg; Ferguson *et al*. 2011). The LW ewes produced wool that was 1 μm broader in fibre diameter than the NP ewes, which is similar to that predicted by the national paddock-scale analysis (0.9 μm for 1 CS difference; Behrendt *et al*. 2011) and the plot-scale analysis (1 μm difference for 10 kg). The effect of ewe CS during pregnancy and lactation on FD was greater than the average measured at the other paddock-scale sites in the Lifetimewool project (Behrendt *et al*. 2011). Conversely, there was a smaller difference between ewe flocks on CFW of the 'Cherrita' ewes compared with the difference reported at the other paddock-scale sites. Nevertheless, the trends were in the same direction and thus support the key message that ewes with a high CS during pregnancy and lactation will produce more, broader wool than ewes with a lower CS during pregnancy.

There was no overall effect of fetal number on ewe fibre diameter. This was not unexpected as LW twin-bearing LW ewes were fed to maintenance during pregnancy and lactation. This enabled them to produce a similar amount of wool with a similar FD to the single-bearing LW ewes. However, it is surprising that no difference in wool production or FD was detected between the single- and twin-bearing ewes in the NP ewe flock.

Conclusion

There are measurable production benefits to twin-born progeny if their mothers are managed as a separate flock to maintain CS during pregnancy. Twin lambs born to ewes managed as a separate mob have liveweight and wool production similar to their single-born counterparts. Wool production from the ewes during pregnancy is also at a level similar to single-bearing ewes. However, not all of the 'twin' penalties can be overcome by differential ewe management during pregnancy; survival of single-born lambs was still higher than twin-born lambs, despite an increase in ewe condition at lambing. In addition, survival of the single-born NP lambs was also higher than the twin-born LW lambs, despite LW ewes having a higher CS during pregnancy and lactation than the NP ewes.

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