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Effects of nutrition and shearing during pregnancy on birth weight in highly fecund Booroola-cross sheep

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ABSTRACT

Effects of liveweight change during pregnancy and ewe shearing on lamb birth weight were studied using highly fecund Booroola-Merino cross Coopworth ewes. Following stratification on the basis of ewe live weight (mean 53.7 kg), age, breed, condition score, and previous (1987) litter size, ewes were randomly allocated to a high (H) or low (L) early pregnancy (0-49days) nutritional treatment. Ewes on treatments L and H were offered sufficient feed to change their average live weight by 0 and 3 kg respectively between mating and 7 weeks post-mating. On the basis of litter size estimated by ultrasound scanning on day 50 of pregnancy, each of the 2 ewe groups was sub-divided and allocated to one of 2 mid-pregnancy nutritional treatments (H and L) designed to change ewe body weight (live weight less conceptus weight) by 3 and 0 kg respectively in 7 weeks. One hundred and nineteen days after mating, half the ewes in each of the 4 nutritional subgroups were shorn and fed to the estimated rmetabolisable energy (ME) equirement of unshorn ewes. Lamb birth weights were recorded twice daily and within 12 hours of birth for 221 lambs born to 102 ewes conceiving at synchronised oestrus.

High level of nutrition of ewes in early pregnancy increased birth weight of lambs by 46($\pm$17) g/kg of live weight gained by ewes in the first 7 weeks of pregnancy ($P < 0.05$). Ewe liveweight change in mid-pregnancy did not affect lamb birth weight ($P > 0.05$).

Shearing of ewes at 119 days after mating tended to increase lamb birth weight but the increase was not statistically significant ($P > 0.05$).

In highly fecund sheep, lamb birth weight was affected by ewe liveweight change in early pregnancy. Nutritional levels that cause a loss of ewe live weight immediately after mating and up to 6 weeks of gestation are detrimental to lamb birth weight.

Keywords Nutrition; ewe; sheep; fecundity; shearing; birth weight; live weight; pregnancy

INTRODUCTION

In highly fecund sheep, individual lamb birth weight is reduced as a result of high litter size (Owens, 1984). As birth weight is the major factor influencing survival (Hinch *et al.*, 1985) an increase in this parameter should have priority as a means of improving lamb survival in high fecundity flocks. Low birth weight of lambs is commonly associated with inadequate ewe nutrition in late pregnancy (Louca *et al.*, 1974; Black, 1983; Smeaton *et al.*, 1985). However, low birth weights have been noted where feeding during late pregnancy was considered to be adequate and where nutritional state, as assessed by concentrations of circulating metabolites, was judged to be satisfactory (Russel *et al.*, 1974). This suggests that nutrition of the pregnant ewe earlier in pregnancy could have a significant bearing on lamb birth weight. Winter shearing of pregnant ewes during the final 10 weeks of gestation has been shown to increase lamb birth weight (Austin, 1977; Vipond *et al.*, 1987). In most of these studies, however, the effects of shearing have been confounded with increases in voluntary feed intake by shorn ewes. Furthermore, little work has been reported on high fecundity sheep under pastoral conditions. This study investigated the effects of nutritional manipulation and shearing of pregnant Booroola-cross ewes on lamb birth weight.

MATERIALS AND METHODS

Two hundred and sixteen synchronised mixed-age Booroola-cross ewes of mean live weight 53.7 kg were mated at a synchronised oestrus. They comprised 50 interbred 1/2 Booroola Merino x 1/2 Coopworth and 166 interbred 1/4 Booroola Merino x 3/4 Coopworth ewes. Following stratification on the basis of ewe live weight, age, breed, condition score, and previous (1987) litter size, the ewes were randomly allocated to a high (H) or low (L) early pregnancy (0-49 days) nutritional treatment. Ewes in treatment H were offered sufficient feed to increase their average live weight by 3 kg between mating and 7 weeks post-mating, to achieve the target live-weight pattern illustrated in Figure 1. Ewes on treatment L were offered a diet aimed at maintaining live weight from mating to 7 weeks post-mating as illustrated in Figure 1.

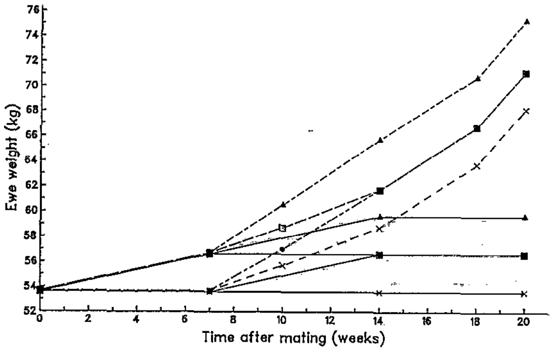

FIG. 1 Target ewe body weight (live weight less conceptus weight)(———) and predicted ewe liveweight pattern (- - - -) from mating to term for nutrition levels that were; high early, high mid-pregnancy (▲) ; high early, low mid-pregnancy (■);l ow early, high mid-pregnancy (•);l ow early, low mid-pregnancy (X).

Both groups were fed the same feed types consisting of ryegrass-white clover and lucerne pasture for the period between mating and 5 weeks post-mating. Thereafter, because of a shortage of pasture, the feed consisted of a base ration of ryegrass/white clover silage supplemented with barley.

Fifty days after mating, the ewes were ultrasonically scanned to determine litter size. After stratification as above, and on the basis of estimated litter size, the 2 ewe groups were sub-divided into 2 equal subgroups, each of which was allocated to one of 2 mid-pregnancy (50-98 days) nutritional treatments (H and L). Target changes in body weight (live weight less conceptus weight) were the same as for the early pregnancy period (see Figure 1). The pattern of liveweight gain predicted to correspond to the target bodyweight pattern is shown in Figure 1.

Ewes were weighed weekly and condition-scored fortnightly to monitor their non-fasted liveweight response to the nutritional treatments. Between 99 and 144 days of gestation, a uniform nutritional treatment aimed at maintaining body weight was applied to all ewe groups by offering them sufficient feed to meet their estimated ME requirement for maintenance and for conceptus growth.

One hundred and nineteen days after mating, approximately half the ewes in each of the 4 nutritional subgroups were shorn. Shorn and unshorn ewes in each subgroup were run together and fed to the estimated ME requirement of unshorn ewes.

Three days before term (approximately 144 days post-mating), ewes were set-stocked for lambing at 22 ewes/ha on ryegrass-white clover pasture with an estimated mass of 1600 kg DM/ha. Lamb birth weight was recorded within 12 hours of birth. Only those lambs born to ewes conceiving at the synchronised oestrus were included in this study (221 lambs, 102 ewes).

Birth weight analyses were performed using a least squares model with the individual lamb as the experimental unit. Main effects tested were; early-pregnancy nutrition, mid-pregnancy nutrition, shearing, litter size, ewe age, ewe breed, lamb sex, mating live weight and day of birth. Backward elimination procedures were followed to give a minimal model. Liveweight differences between nutritional groups were analyzed using student's t-test in MINITAB.

In addition , a covariance analysis was performed with the covariates being ewe liveweight changes from 0-49, 50-98 and 99-144 days after mating. The data were first corrected for birth rank, birth date and ewe mating live

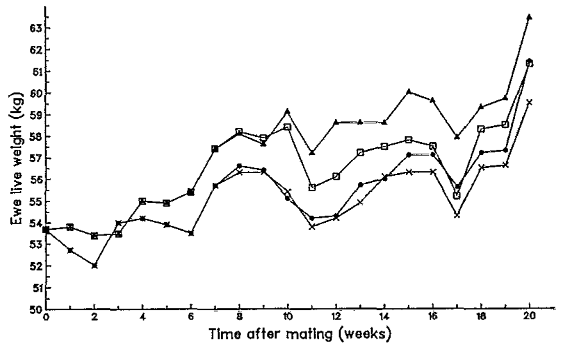

FIG. 2 Pattern of ewe liveweight gain from mating to term for nutrition levels that were; high early, high mid-pregnancy (▲) ; high early, low mid-pregnancy (■);l ow early, high mid-pregnancy •); low early, low mid-pregnancy (X).

weight.

RESULTS

The pattern of ewe liveweight gain from mating to term is illustrated in Figure 2. Liveweight changes for the H and L groups over the early pregnancy period are shown in Table 1. Ewes in the L group gained approximately 2 kg live weight despite the relative restriction to intake imposed on them. This resulted from a sharp increase in mean live weight between weeks 6 and 7. In spite of this, there was a significant difference ($P < 0.05$) in liveweight change (0-7weeks) between H and L groups (3.7 ± 0.2 kg *v* 2.3 ± 0.2 kg respectively). Differences in liveweight change (Table 1) between H and L groups (0.85 ± 0.31 kg *v* 0.42 ± 0.26 kg) were not statistically significant ($P > 0.05$).

TABLE 1 Mean (±SEM) ewe liveweight change (kg) for high and low nutritional groups over early- and mid-pregnancy

Pregnancy interval	High	Low	Significance of difference
0 - 49 days	3.70 ± 0.20	2.38 ± 0.17	*
50 - 98 days	0.85 ± 0.31	0.42 ± 0.26	NS

TABLE 2 Least squares means of lamb birth weight

Treatment level		Number of lambs	Lamb birth weight(kg)	SE	Level of significance
Early pregnancy nutrition					
	High	121	3.30	0.10	
	Low	100	3.03	0.09	*
Mid-pregnancy nutrition					
	High	98	3.24	0.09	
	Low	123	3.09	0.11	NS
Shearing					
	Shorn	113	3.19	0.09	
	Unshorn	108	3.14	0.10	NS
Litter size					
	Single	25	4.22	0.16	
	Twins	84	3.17	0.09	
	Triplets	84	2.86	0.10	
	Quadruplets	28	2.42	0.17	**
Regression on					
	Initial ewe live weight (g kg^{-1})		35	7	**
	Birthday (g d^{-1})		103	17	**

Early-pregnancy nutrition affected lamb birth weight (Table 2) with high level of nutrition in early pregnancy resulting in a higher mean birth weight (3.30 ± 0.09 kg *v* 3.03 ± 0.10 kg ($P < 0.05$)). High mid-pregnancy nutrition tended to increase lamb birth weight but the effect was not statistically significant.

Shearing ewes at 119 days after mating tended to increase lamb birth weight but the increase was not statistically significant.

Of the other factors included in the model, only litter size affected lamb birth weight which declined with increasing number of lambs ($P < 0.01$).

Liveweight change in early pregnancy affected ($P < 0.05$) lamb birth weight (Table 3) with birth weight increasing by 46 (± 17) g/kg live weight gained by ewes during this period. Ewe liveweight

TABLE 3 Regression of lamb birth weight (g) on ewe liveweight change (kg) during intervals in pregnancy.

Pregnancy interval	Regression coefficient(g kg^{-1})	SE of regression coefficient	Level of signif.
0-49 days	46	17	*
50-98 days	25	24	NS
99 days-term	111	16	**

change in mid-pregnancy had no significant effect on lamb birth weight. Change in lamb birth weight per unit change in ewe live weight in late pregnancy (99-144 days) was 111(± 16) g/ kg.

DISCUSSION

Lamb birth weight may be sensitive to ewe liveweight change in early pregnancy; in this study differential feeding of ewes generated a 1.32 kg difference in ewe live weight between the 2 groups and resulted in a 0.27 kg difference in lamb birth weight. This result was supported by the analysis of covariance which indicated a 46 g increase in lamb birth weight per kilogram change in ewe live weight during this period. The liveweight difference between H and L groups was 1.90 kg at week 6 but this difference dropped to 1.32 due to an increase in mean live weight of L group ewes between weeks 6 and 7 (see Figure 2). The liveweight patterns also show that ewes on the low plane of nutrition lost approximately 0.8 kg live weight in the week immediately following mating and had lost approximately 1.5 kg by day 14 of gestation. Ewes on the higher plane maintained live weight in the week immediately following mating and had lost approximately 0.4 kg by day 14 of gestation. From these liveweight changes, it is reasonable to speculate that the observed difference in lamb birth weight was caused by ewe liveweight changes occuring within the first 6 weeks of gestation. It is also reasonable to speculate that larger differences in lamb birth weight may have resulted had the target liveweight difference been achieved. The liveweight changes which occured in the L group may have retarded foetal growth and development and led to adverse consequences on the subsequent growth of the foetus. The period from mating to 35 days post-mating is one of rapid specific growth of the foetus (Dingwall *et al.*, 1987) and sheep embryos are sensitive to maternal nutrition during this period (Parr *et al.*, 1982). Although the foetus is capable of compensatory growth following a period of restriction (Parr *et al.*, 1986; Faichney and White, 1987), once foetal organs have passed through sequential phases of development they may be precluded from full compensatory development later in foetal life (Parr and Williams, 1982).

There is evidence (Dingwell *et al.*, 1987) that nutrition in early pregnancy affects cotyledon size and weight and a correlation of 0.72 has been established by these workers between cotyledon weight and foetal weight at day 60 of gestation. In addition to its possible effects on foetal size and development, it is possible to speculate that the higher level of nutrition during the early pregnancy period increased the total weight of foetal cotyledons per foetus and hence the capacity of the foetus for nutrient exchange and growth both during this period and later in gestation.

The difference in live weight between H and L groups at the end of mid-pregnancy was 0.5 kg and was not statistically significant. The higher plane of nutrition resulted in higher lamb birth weight but the difference was not statistically significant ($P > 0.05$). These observations are supported by the the covariance analysis which showed no significant effect of ewe liveweight change in mid-pregnancy on lamb birth weight. A similar relationship between mid-pregnancy nutrition and lamb birth weight has been reported by Monteath (1971), Chandler *et al.* (1985), Gunn *et al.* (1986) and Hawker and Thompson (1987). In the study of Monteath (1971), differential feeding in mid-pregnancy resulted in a reduction of ewe live weight up to 16% of initial live weight without any significant effects on lamb birth weight, indicating the considerable ability of the ewe to buffer nutritional insults in mid-pregnancy.

There was no significant effect of shearing on lamb birth weight. Shearing may increase lamb birth weight by modifying the endocrine balance of the ewe so that there is an increased supply of glucose to the foetus (Thompson *et al.*, 1982) and it has been suggested by Symonds *et al.* (1988) that the magnitude of the ewe's response to shearing varies with time and is greatest between 2-3 weeks after shearing. The intensity and duration of this response could thus determine the extent to which lamb birth weight is affected. It is possible that in the present study, shearing was performed too close to term for it to achieve a significant effect. It is equally possible that the response of the ewes to the shearing treatment was reduced because glucose production was already elevated as a result of high litter size.

CONCLUSION

The results of this study indicate that in highly fecund sheep, lamb birth weight can be affected by nutrition of the pregnant ewe during early pregnancy. Common management practices which result in loss of ewe live weight immediately after mating and up to 6 weeks post-mating could thus have detrimental effects on lamb birth weight and survival and are therefore not acceptable. In the present study, a birth weight difference of 0.27 kg was achieved with relatively small differentaial feeding regimes. In lambs from large litters with low mean birth weights such a difference could be critical in raising birth weight to the threshold necessary for improved chances of lamb survival and is therefore of biological significance. In prolific ewes, abdominal space available for the rumen is likely to be reduced in late pregnancy (Forbes, 1969). The ability to alter lamb birth weight by variation in late pregnancy nutrition is therefore limited. Nutritional manipulation of ewes in early pregnancy presents a useful means for ensuring higher birth weight of lambs and thus improved chances of survival in lambs from large litters.

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