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The Effect of Ewe Body Condition at Lambing on Colostral Immunoglobulin G Concentration and Lamb Performance^{1,2}

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ABSTRACT: Body condition was scored at lambing (BCSL) on 101 mature (4 to 7 yr old) Polypay ewes and related to colostral immunoglobulin G (IgG) concentration and lamb performance. Colostrum samples were collected from each ewe within 12 h of lambing and litters of more than two lambs were reduced to two within 2 h of lambing. Colostral IgG concentrations decreased rapidly with time ($b = -3.28$; $R^2 = .2132$) and linear regression analysis projected that colostral IgG concentrations would diminish to zero milligrams/milliliter by 23 h postpartum. Body condition score at lambing varied from 2.5 to 3.5 and had no effect on colostral IgG concentration, which averaged 79 ± 5.6 mg/mL, adjusted to the time of parturition. Total birth weights of lambs were higher for the oldest ewes (7 yr old), but this group had the lowest prolificacy. This age group weaned the lowest

total lamb weight and number of lambs. Total weight of lambs born was not affected by BCSL. Lamb mortality from birth to weaning was 19.0% and was not affected by BCSL, sex, litter size, or breed of sire, but the older (7 yr old) ewes had greater lamb mortality. Total weight of lamb weaned was not affected by BCSL, although ewes with a BCSL of 3.0 tended ($P = .11$) to wean more kilograms of lamb than ewes with a BCSL of 3.5. Ewes bred to Polypay rams weaned more total weight of lamb than those bred to Columbia rams, which was due to increased survival rate to weaning for the Polypay rams. We conclude that, within a range of 2.5 to 3.5, BCSL is not an important factor affecting the colostral IgG concentration, total weight of lamb born, lamb mortality, or total weight of lamb weaned.

Key Words: Ewes, Weaning Weight, Lamb, Mortality, Colostral Immunity, Immunoglobulin G

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Introduction

Body condition score (**BCS**) is a better predictor of body fat than live weight (Russel et al., 1969; Sanson et al., 1993). Ewes with low BCS have been associated with higher prenatal (West et al., 1989) and neonatal mortality (Nordby et al., 1986) and lower lamb survival (Khan, 1994).

Colostrum is the first secretion from the mammary gland after parturition. The primary immunoglobulin in colostrum is immunoglobulin G (**IgG**) (Smith et al., 1975) and the concentration of immunoglobulins in colostrum decreases rapidly after parturition (Shubber et al., 1979). Colostrum provides passive

immunity to the lambs, which is correlated with their resistance to infections (Halliday, 1974) and is essential for their survival (Khalaf et al., 1979b). Little is known about the relationship between BCS and colostral IgG concentrations, although Thomas et al. (1988) failed to observe a significant affect of BCS on colostral IgG concentration.

The purpose of this experiment was to characterize the decline in colostral IgG following parturition and to examine the relationship between BCS at lambing (**BCSL**) in Polypay ewes and colostral IgG concentration and weight of lamb weaned per ewe.

Materials and Methods

During gestation, 101 mature (4 to 7 yr old) Polypay ewes (half mated to Polypay and half mated to Columbia rams) were grazed on a mixed grass-clover pasture. At 2 wk before lambing, the ewes were moved to the lambing barn, where they were fed .91 kg corn daily and grass-clover hay to appetite.

Ewes were scored for body condition weekly during the last month of gestation and the last BCS before

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parturition was considered to be the BCSL. The body condition score was based on a 5-point scale with half-point gradations, where 1 is very thin and 5 is obese (Russel et al., 1969).

Lambs were allowed to nurse after parturition. Within 2 h of lambing, multiple litters were reduced to two lambs of similar body weight, regardless of sex, to nurse each ewe. Within 2 d following parturition any lambs that were doing poorly due to inadequate milk production by the ewe were also removed. Colostrum samples (approximately 15 mL from each half of the udder) were obtained from each ewe by hand milking within 12 h of lambing. Lambs were weighed at birth (total litter) and at weaning (singlets or adjusted to twins). Ewes and lambs remained in the lambing barn for 2 to 3 wk after lambing, during which time the ewes received the prelambing diet. After this time, the ewes, with their lambs, were returned to the mixed grass-clover pasture. Weaning occurred at 95 d postpartum. Lamb survival was calculated from the number of lambs born that were present at weaning. The lambs that were removed from ewes to adjust litter size to two were not included in this statistic.

Colostrum IgG concentrations were measured using radial immunodiffusion (Mancini et al., 1965) as modified by Fahey and McKelvey (1965). Radial immunodiffusion plates and reagents, specific for ovine immunoglobulin G, were purchased from The Binding Site (Birmingham, U.K.). Five microliters of colostrum, diluted 1:40 to 1:160 in 7% BSA, was applied to each well. A IgG standard was included in each plate. Ring diameters were determined to the nearest .1 mm, using a calibrated 7 \times magnified eyepiece, after incubation at room temperature for 72 h.

Data were analyzed by least squares analysis of variance using the GLM procedure of SAS (1988) with all main effects regarded as fixed. The model included BCSL, ewe age, breed of mating sire, litter size, and all interactions. Sex of lambs and most interactions were not included in the final model because preliminary analysis indicated levels of $P > .50$. Litters of four and five were combined with triplets because there were only nine and two ewes with quadruplets and quintuplets, respectively. All data are presented as least squares means (\pm SEM). Colostrum IgG concentration was adjusted by covariance analysis for the time interval from parturition to collection of colostrum. Total birth weight (singlets, twins, or adjusted to twins) was used as a covariate for analysis of weaning weights of lambs. Pearson correlation coefficient analysis was used to measure the degree of relationship between variables. Linear regression analysis was used to relate IgG concentrations to time postpartum.

Results and Discussion

Colostrum IgG concentrations decreased ($P < .001$) with time after parturition (Figure 1, $r = -.46$, $P <$

.001). Linear regression analysis projected IgG concentrations decreasing to 0 mg/mL by 23 h postpartum. Shubber et al. (1979) collected colostrum at 6-h intervals for 48 h after parturition and reported that total immunoglobulin concentrations (IgG₁, IgG₂, IgM, and IgA) were very low by 36 h after the first feeding. The decrease in colostrum immunoglobulins after parturition that we and Shubber et al. (1979) observed is similar to that reported in dairy cattle (Stott et al., 1981). Stott et al. (1981) observed that IgG concentrations decreased about 50% with each milking (12 h intervals) and that IgG concentrations were not different after the second milking (12 h postpartum). Immunoglobulin G is of similar homology in cattle and sheep. It is believed to be transported directly from blood to lacteal secretions, primarily before parturition, although it is present in milk throughout lactation (Butler, 1969). Thus, the fact that some of our ewes were suckled before sampling probably had no effect on the IgG concentrations we are reporting.

Colostrum IgG concentrations were not affected by BCSL, breed of sire, or litter size (Table 1). The mean concentration was 79 ± 5.6 mg/mL, adjusted to the time of parturition; individual samples ranged from a low of 14 mg/mL to a maximum of 114 mg/mL. Our results agree with those of Thomas et al. (1988), who also failed to detect differences in colostrum IgG concentrations in 3-yr-old Finn-Targhee ewes with BCSL of 2.5 or 3.5. Mellor and Murray (1985a) and Khalaf et al. (1979a) reported that underfeeding during late pregnancy reduced the volume of colostrum produced. These authors did not report concentrations of colostrum immunoglobulins. Our concentrations of colostrum IgG are similar to those of Gilbert et al. (1988) and Thomas et al. (1988) but lower than

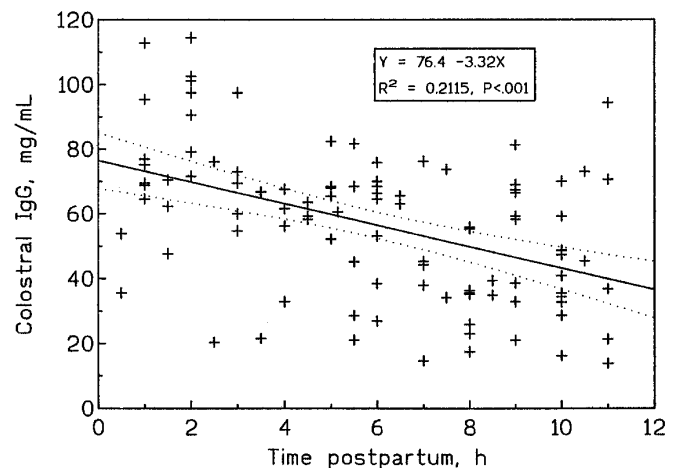


Figure 1. Linear regression of colostrum immunoglobulin G (IgG) concentrations on time of collection following parturition. The dotted lines represent the 95% confidence interval of the regression line.

Table 1. Least squares means and standard errors of colostral immunoglobulin (IgG) concentrations (adjusted to time 0), total weight of lambs born (1, 2, ≥ 3) and total weight of lambs weaned (0,1,2) at 95 days of age as affected by body condition score at lambing (BCSL), age of ewe, breed of mating sire and litter size

Category	n	IgG, mg/mL	Birth weight, kg	Weaning weight, kg
BCSL				
2.5	38	78 \pm 6.1	8.7 \pm .33	43.1 \pm 3.15
3.0	35	79 \pm 6.5	8.7 \pm .30	47.6 \pm 2.85
3.5	28	79 \pm 6.6	8.2 \pm .34	41.3 \pm 3.55
Age of ewe				
4 yr	26	74 ^{ab} \pm 6.2	8.3 ^a \pm .35	46.8 ^a \pm 3.55
5 yr	20	85 ^b \pm 7.1	8.1 ^a \pm .39	44.6 ^a \pm 3.84
6 yr	34	72 ^a \pm 6.2	8.4 ^a \pm .32	51.5 ^a \pm 3.13
7 yr	21	83 ^{ab} \pm 7.7	9.4 ^b \pm .41	33.3 ^b \pm 3.76
Breed of mating sire				
Polypay	52	77 \pm 6.2	8.4 \pm .28	50.2 ^a \pm 2.79
Columbia	49	81 \pm 5.8	8.6 \pm .27	37.8 ^b \pm 2.70
Litter size				
1	8	79 \pm 9.6	5.1 ^a \pm .57	41.0 \pm 6.11
2	58	78 \pm 4.6	9.0 ^b \pm .21	44.7 \pm 2.14
≥ 3	35	79 \pm 6.0	11.5 ^c \pm .30	46.4 \pm 2.87

^{a,b,c}Means in column within a category with different superscripts differ ($P < .05$).

those reported by Hunter et al. (1977), Gentry et al. (1992), McGuire et al. (1983), and Shubber et al. (1979).

A large study by Gilbert et al. (1988) reported that colostral IgG concentrations were higher in yearling than in older ewes and higher in ewes of the Polypay breed than in ewes of the other breeds they studied. In our study of mature ewes, colostral IgG tended to be higher in 5- and 7-yr-old ewes than in 4- and 6-yr-old ewes.

Gilbert et al. (1988) observed a linear increase in colostral IgG concentration as litter size increased from singles to triplets; we failed to detect such trends.

Thomas et al. (1988) did not observe an effect of litter size on colostrum volume or colostral IgG concentrations. Gallo and Davies (1987), however, reported that ewes giving birth to twins or multiples produced a greater volume of colostrum than ewes giving birth to single lambs.

Body condition score at lambing had no effect on total litter weight of lambs born (Table 1), but a difference in prolificacy was noted between BCSL 2.5 and 3.5 (Table 2). Ewes with the highest BCSL (3.5) had the lowest litter size ($r = -.25$), and litter size was highly correlated ($r = .72$) with birth weight (Table 3). The 7-yr-old ewes produced the highest

Table 2. Least squares means and standard errors of prolificacy, lambs weaned per ewe exposed, and lamb survival as affected by body condition score at lambing (BCSL), age of ewe, and breed of mating sire

Category	Prolificacy	Lambs weaned	Lamb survival %
BCSL			
2.5	2.60 ^a \pm .14	1.57 ^{ab} \pm .09	78.61 \pm 4.79
3.0	2.24 ^{ab} \pm .14	1.64 ^a \pm .09	88.01 \pm 4.84
3.5	2.16 ^b \pm .16	1.34 ^b \pm .11	76.29 \pm 5.59
Age of ewe			
4	2.59 ^a \pm .16	1.51 ^{ab} \pm .11	80.21 ^{ab} \pm 5.84
5	2.11 ^b \pm .18	1.50 ^{ab} \pm .12	84.95 ^b \pm 6.34
6	2.52 ^a \pm .13	1.80 ^a \pm .10	91.63 ^b \pm 4.87
7	2.11 ^b \pm .18	1.27 ^b \pm .12	67.09 ^a \pm 6.28
Breed of mating sire			
Polypay	2.40 \pm .11	1.71 ^c \pm .08	86.15 \pm 4.18
Columbia	2.27 \pm .12	1.32 ^d \pm .08	75.78 \pm 3.98

^{a,b}Means in column within a category with different superscripts differ ($P < .05$).

^{c,d}Means in column within a category with different superscripts differ ($P < .01$).

Table 3. Correlation coefficients for ewe and lamb characteristics^a

	TWBF	TWBA	WWT	IgG	HR	AGE	LITTER	TRN	DL12	DED
BCSL	-.25**	-.10	-.03	-.03	.05	.22*	-.25**	-.23*	.08	-.16
TWBF		.48**	.25**	.10	-.10	.07	.72**	.46**	.08	.14
TWBA			.32**	.09	-.17 [†]	.32**	-.17 [†]	.39**	-.19 [†]	.06
WWT				-.16	-.07	.00	.07	.67**	-.36**	-.63**
IgG					-.46**	-.02	.08	-.06	.15	.12
HR						.11	-.05	-.14	.08	.00
AGE							-.17 [†]	-.01	.04	.02
LITTER								.29**	.33**	.08
TRN									-.43**	.02
DL12										-.00

^aBCSL = body condition score at lambing; TWBF = unadjusted total weight of lambs born; TWBA = adjusted total weight of lambs born; WWT = total weight of lambs weaned; IgG = immunoglobulin concentration; HR = time interval from lambing to colostrum collection; AGE = age of the ewes; LITTER = unadjusted litter size; TRN = number of lambs turned out to pasture; DL12 = number of lambs died before adoption; DED = death loss after turned out to pasture.

[†] $P < .10$.

* $P < .05$.

** $P < .01$.

total weight of lambs born, whereas total weight of lambs born was similar for the 4-, 5- and 6-yr-old ewes.

Thomas et al. (1988) compared ewes with BCS (2.5 and 3.5) similar to those in our experiment and noted that ewes with the higher BCS produced 10% more total birth weight. Poor or limited nutrition during mid or late pregnancy has been implicated with low birth weights in some studies (Peart, 1967; Russel et al., 1981; Mellor and Murray, 1985b), whereas other studies failed to establish a relationship (Gibb and Treacher, 1982; Hall et al., 1992; Kleemann et al., 1993). However, as discussed by Russel et al. (1981), the level of nutrition during late pregnancy has a greater effect on lamb birth weight than the level of nutrition during mid-pregnancy (2nd and 3rd mo). Nutritional status had a more important bearing on lamb birth weight in younger ewes than in older ewes (Russel et al., 1981). Our results are in agreement with those of Russel et al. (1981), who found that, in one experiment, ewes with a higher BCS had lambs with lower birth weights. Russel et al. (1981) indicated that there may be a threshold of body condition beyond which a high level of nutrition has a negative effect on individual lamb birth weight, because the ewe adds maternal body weight rather than lamb birth weight.

Lamb survival (Table 2) from birth to weaning (d 95) was not affected by BCSL or breed of sire but tended to be lower for lambs from the 7-yr-old ewes than from lambs of ewes of other ages. Death loss from natural causes was 19.0%, including lambs that died before multiple litters were adjusted to twins. Of the lambs that died, the majority (57%) of lambs were dead at birth or died within 2 to 3 h of birth. Predator kill (mostly coyotes) totaled 2.1% from pasture turnout to weaning. Gilbert et al. (1988) reported a death loss of 12.3%, of which 52% died of infectious diseases. Others (Khalaf et al., 1979b; McGuire et al.,

1983; Gentry et al., 1992) have reported similar death losses. Hall et al. (1992) noted a higher survival rate of lambs when ewes of moderate body condition were supplemented during late gestation, although Kleemann et al. (1993) found no effect of the plane of nutrition during mid and late pregnancy on birth weight or lamb survival.

A relationship has been observed between the level of nutrition during pregnancy and embryonic (West et al., 1989) or perinatal (Khalaf et al., 1979a) mortality. We observed a negative relationship ($r = -.19$) between early death loss (< 12 h) and adjusted total weight of lamb born, indicating that perinatal death loss was lower in lambs with a heavier birth weight (Table 3). A negative correlation ($r = -.63$) between death loss in pasture (largely predator kill) and total weaning weight can be attributed to the higher weaning weight of surviving lambs.

Body condition score at lambing had no effect on total weight weaned (Table 1); however, ewes with a 3.5 BCSL weaned fewer lambs than ewes with a 3.0 BCSL (Table 2). Because no differences were noted in lamb survival due to BCSL, the difference noted in fewer lambs weaned is likely related to the decreased prolificacy for the 3.5 BCSL group. The oldest ewes (7 yr old) weaned the lowest total lamb weight and tended to wean the lowest number of lambs. Total weaning weights of purebred Polypay lambs were higher than weaning weights of crossbred lambs (Polypay \times Columbia), primarily because of the greater survival rate for the Polypay-sired lambs. Lewis and Burfening (1988) found greater survival rate to weaning in 1/4 Finn crossbred ewe lambs compared with whitefaced breeds that included Columbia. Thus, the level of Finn breeding in the Polypay breed may account for the difference. Hall et al. (1992) reported that supplementation of ewes in moderate condition during late pregnancy had no effect on weaning weights of lambs.

Implications

Ewe body condition score at lambing, ranging from 2.5 to 3.5 (1 to 5 scale; 1 = very thin), had no effect on colostral immunoglobulin G (IgG) concentrations, lamb mortality, or total weight of lamb weaned. Colostral IgG levels decreased rapidly after parturition (approximately $3.3 \text{ mg}\cdot\text{mL}^{-1}\cdot\text{h}^{-1}$). If ewes are in a moderate (2.5 to 3.5) body condition score at lambing, the goal should be to maintain this condition rather than supplementing to increase the body condition score to a higher level.

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