

THE INFLUENCE OF PRENATAL NUTRITION ON POSTNATAL PERFORMANCE OF MERINO LAMBS

D. E. TAPLIN* and G. C. EVERITT*

I. INTRODUCTION

There is considerable evidence to show that body and fleece characteristics of lambs may be influenced by prenatal nutritional history (reviewed Thomson and Aitken 1959; Schinckel 1963). The earliest stage of gestation at which maternal undernutrition restricts postnatal performance of the progeny requires definition.

Recent work has shown that foetal weight in the sheep can be depressed by 90 days of gestation through gross undernutrition of the pregnant ewe (Everitt 1964.); Schinckel (1963) found a significant difference in weight at 90 days between single and multiple Merino foetuses.

The purpose of this study was to examine the residual effects of severe maternal undernutrition in the first 90 days of pregnancy on postnatal productivity of single lambs. Early postnatal conditions were standardised by artificially rearing the lambs from birth to 12 weeks of age.

II. MATERIALS AND METHODS

(a) Prenatal Nutrition

In November 1962, 100 three-year-old South Australian Merino ewes were randomized into four equal groups, and mated to Merino rams. During pregnancy the ewes were subjected to four nutritional regimes (HH, a high plane throughout; HL, a high plane for the first 90 days followed by a low plane to lambing; LH, a low plane for the first 90 days followed by a high plane until lambing; LL, a low plane throughout. The experimental objective was a 25 % gain (HH, LH) or loss (HL, LL) in gross body weight achieved by controlled grazing during the first 140 days of pregnancy, after which a supplementary concentrate feed was offered *ad libitum* to all ewes in order to reduce losses.

Three male and three female lambs in each group were chosen for artificial rearing from ewes most closely approximating the desired body weight gains or losses, and all data presented refer to these ewes or their lambs.

(b) Postnatal management

(i) Feeding and Management

The selected lambs were artificially reared on diluted cow's milk mixture fed at levels proportional to body weight ^{0.73} (Table 1) from 2 days to 12 weeks of age.

*Waite Agricultural Research Institute, University of Adelaide,

TABLE 1
Volume and frequency of feeding lambs

Age Interval (days)	Vol. Milk Mixture (ml.)/Feed [†]	No. Feeds/Day [‡]
Birth-8	95.4W ₀ ^{0.73}	3
8-11	113.4W ₈ ^{0.73}	3
11-63	139.6W ₁₁ ^{0.73}	3
63-73	139.6W ₁₁ ^{0.73}	2
73-84	139.6W ₁₁ ^{0.73}	1

[†]W₀ = body weight at birth

W₈ = body weight at 8 days of age

W₁₁ = body weight at 11 days of age

[‡]Milk mixture:—4 parts cows' milk : 1 part water

A dry pelleted ration (50% barley, 45% lucerne, 3 % ground limestone, 2% common salt) was offered **ad libitum** to all lambs from 2 to 12 weeks of age.

Weaning onto pasture took place at 12 weeks, and the lambs were shorn at 20 weeks of age.

(ii) Measurements

Body weights were recorded at weekly intervals from birth to 12 weeks of age, and again at 20 weeks of age.

The following body measurements (Cloete 1939; Turner *et al* 1953; Hunter 1956) were recorded at birth, at fortnightly intervals for 12 weeks and again at 20 weeks of age:—curved crown-rump length (birth only), body length (**tuber scapulae—tuber ischii**), chest circumference and depth, forecannon circumference and length, leg length (olecranon process-first interphalangeal joint)? width of hooks(**tuber coxae**) and hooks to pins (**tuber ischii**).

Wool follicle development was examined in histological sections from biopsy skin samples, 1 cm in diameter, taken from the **midside** at birth, 2 and 12 weeks of age.

A 4 x 4 cm **midside** patch was tattooed on all lambs at birth. The wool war harvested and the patch measured at 32 and 20 weeks of age. Total wool output was measured at 20 weeks.

(c) Biometrical Procedures

Treatment effects have been examined by analysis of variance, with the primary comparisons of plane of nutrition before (H/- v. L/-) and after (-/H v. -/L) 90 days of gestation, of male v. female, and the interactions.

Sex effects and interactions were neither appreciable nor consistent and have been ignored in the presentation of results.

III. RESULTS

(a) Ewe Performance

Mean relative and absolute body weights of ewes during 140 days of pregnancy are shown in Figure 1.

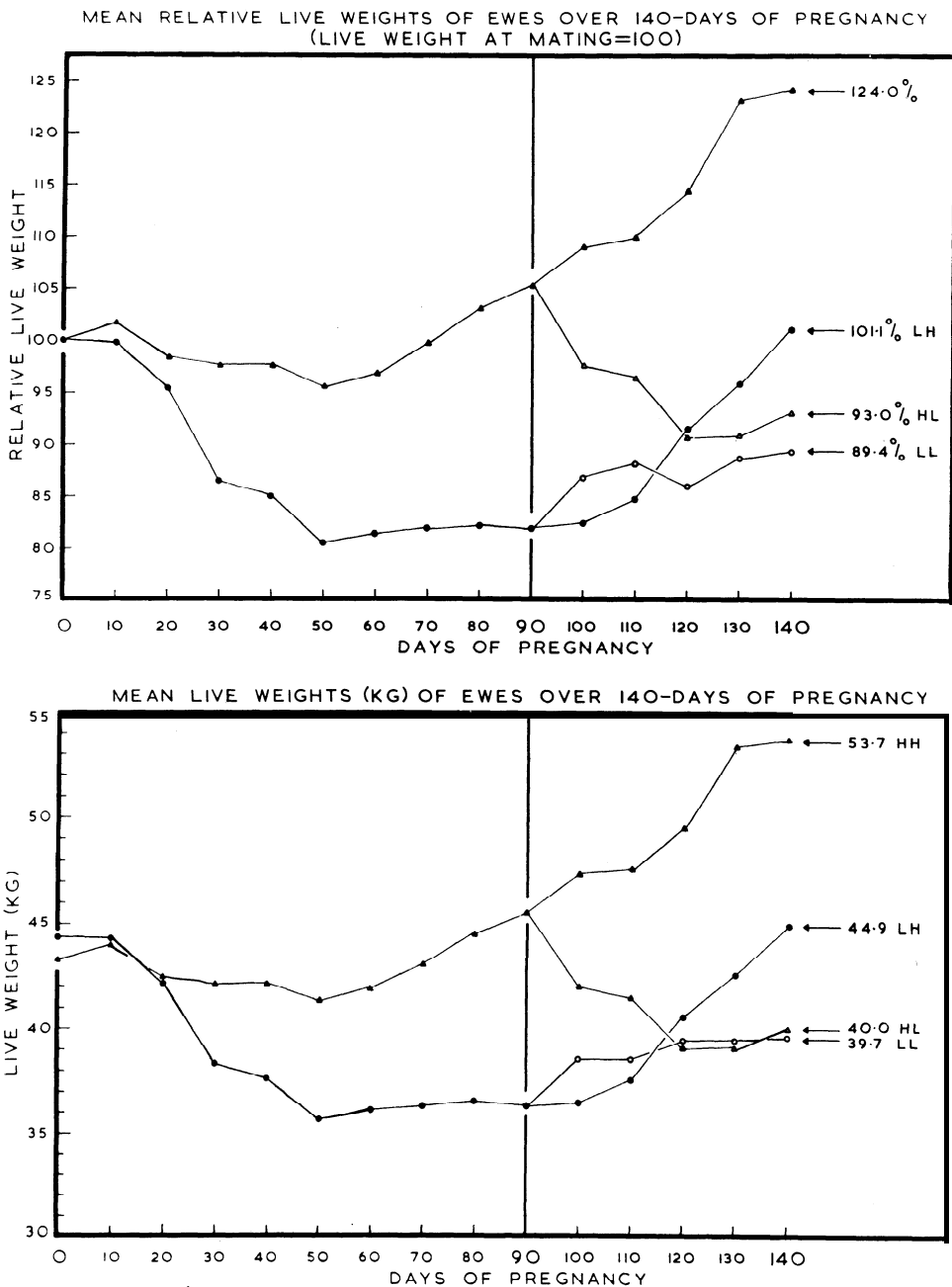


Fig. 1.-Mean relative and absolute live weights of ewes during 140 days of pregnancy.

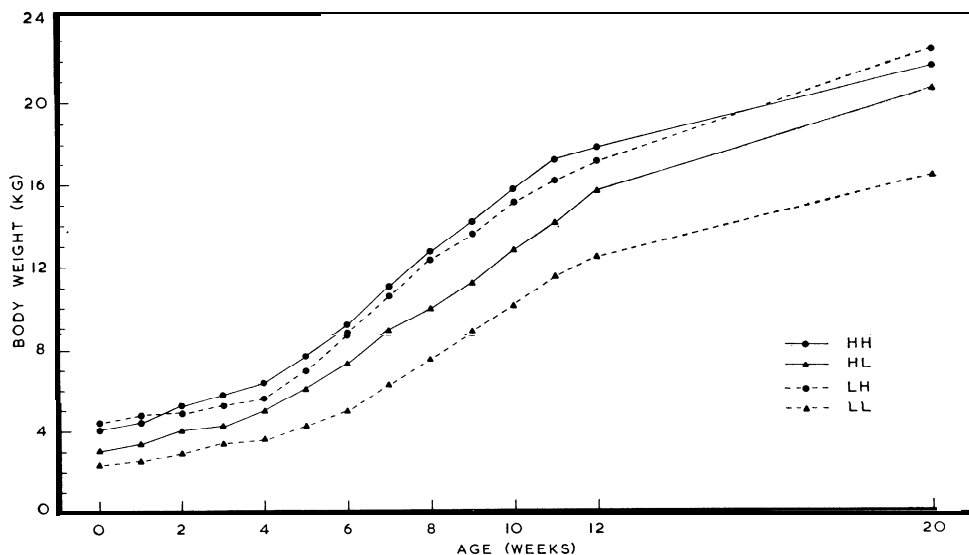


Fig. 2.—Mean growth curves of lambs from birth to 20 weeks of age.

Post-partum mean body weight of $-/L$ ewes (35.5 kg) was notably less than that of either HH (45.0 kg) or LH (40.2 kg) ewes.

Length of gestation was not significantly affected by treatment, the mean duration for selected ewes being 149.9 days.

Four LH ewes aborted in late pregnancy.

(b) Lamb body weight

Mean growth curves of the lambs to 20 weeks of age are shown in Figure 2.

Birth weight of $-/L$ lambs was markedly ($P < 0.001$) less than that of their $-/H$ fellows (HH-4.16; HL—3.05; LH-4.26; LL-2.39 kg).

Throughout the first 20 weeks of life $-/H$ lambs were significantly heavier than $-/L$ lambs, but the latter grew faster on a percentage basis. Thus at 20 weeks of age $-/L$ lambs were six to seven times heavier than at birth, while $-/H$ lambs made a four to five fold **gain**. However, LL lambs gained less weight on an absolute basis.

(c) Body dimensions

Mean body dimensions are plotted against age in Figure 3. Mean values at birth of $-/L$ lambs have been expressed as percentages of the $-/H$ values in Figure 4.

The body conformation of LL lambs, in particular, differed noticeably from that of their fellows at the same age. Figure 4 shows that the various dimensions at birth in $-/L$ lambs were retarded in an order of magnitude similar to that expected under the general concept of allometric growth.

The close affinity between the mean body weight curves (Figure 2) and the dimensions on an age basis (Figure 3) may be noted. In Figure 5 the mean body dimensions are plotted against body weight. At 6 kg body weight LL lambs were

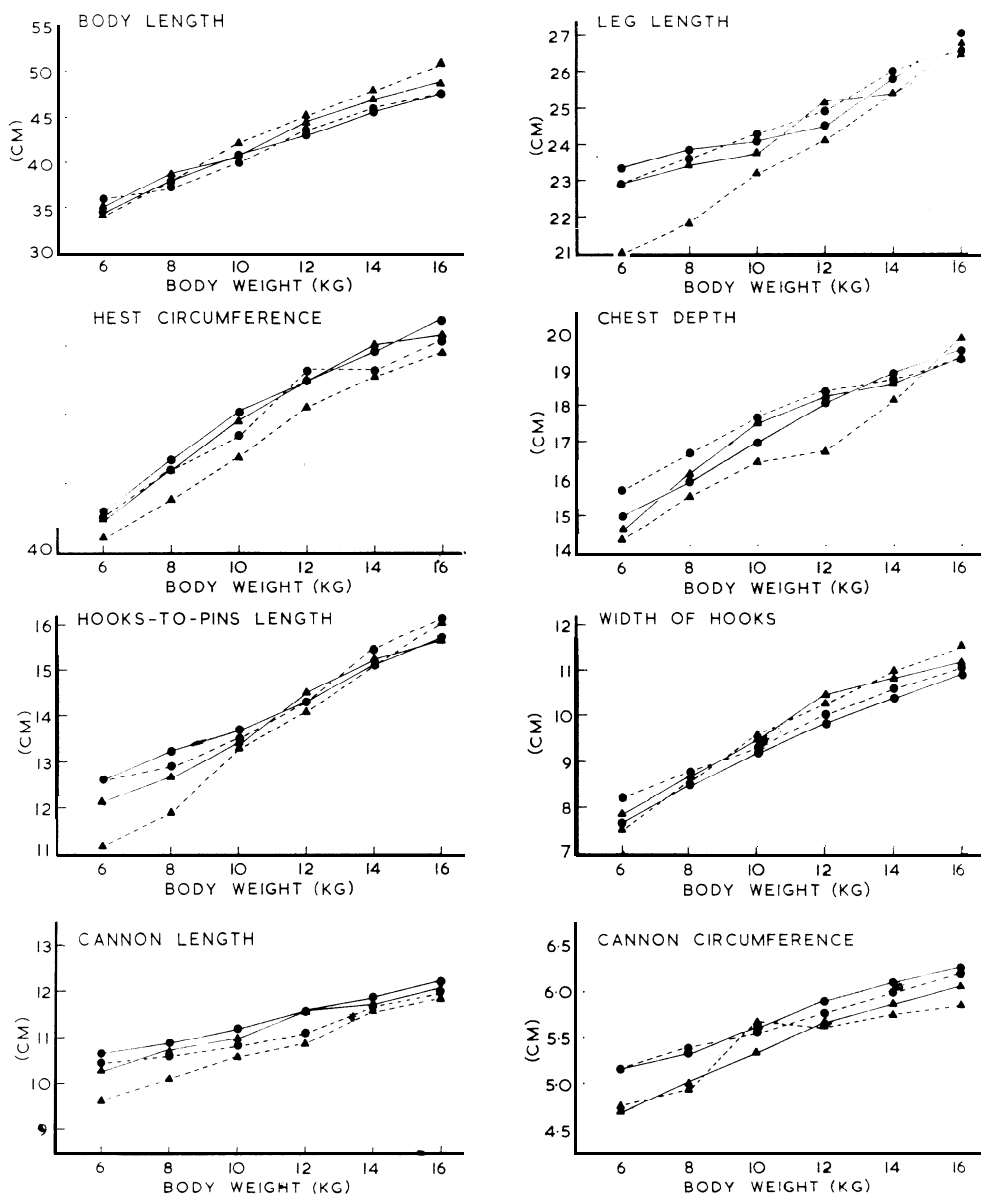


Fig. 3.—Mean body dimensions plotted against age.
 Legend: HH —●—, HL —▲—, LH - - ● - - , LL - - ▲ - - .

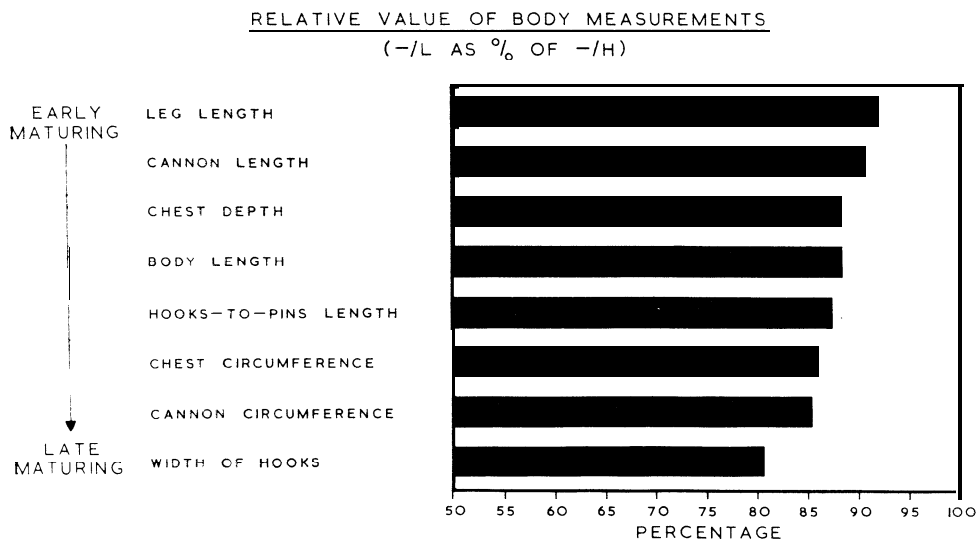


Fig. 4.-Relative values of mean body dimensions at birth:

short in the leg, with little difference in other dimensions. At 16 kg body weight no large differences in body conformation were apparent.

(d) Wool follicle development

Mean numbers of mature wool follicles and follicle ratios are recorded in Table 2.

(i) Primary follicles

The number of primary wool follicles (Pf) per unit area of skin was higher in -/L lambs than in their -/H fellows.

The total number of primary follicles at birth was significantly lower in -/L lambs than in -/H lambs. Differences at later samplings were not significant.

(ii) Secondary follicles

The density of mature secondary follicles (Sf) at birth was affected by the planes of nutrition both before and after 90 days of gestation. Differences were not significant at later samplings.

Secondary follicle population showed the same trend with age, i.e., treatment significance at birth but no significant effects at 12 weeks of age.

(iii) Follicle ratios

At each sampling the mature Sf/Pf ratio of -/H lambs exceeded that of -/L lambs.

(e) Wool production

Mean wool production data is shown in Table 3.

The amount of clean wool per unit area of skin at birth, and the estimated clean weight of birthcoat, was less from -/L than from -/H lambs.

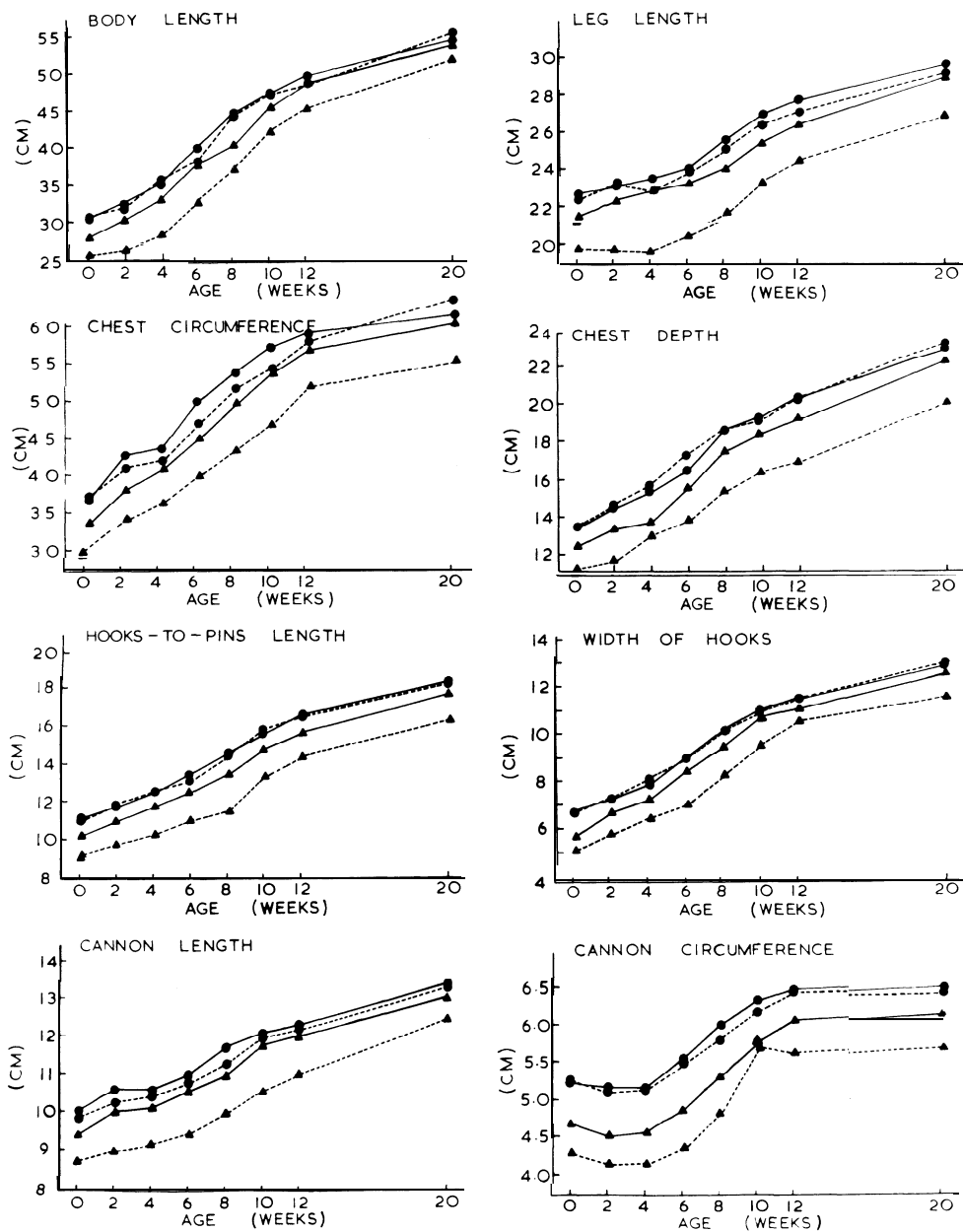


Fig. 5.—Mean body dimensions plotted against body weight. Legend as for Fig. 3.

TABLE 2

Mature follicle numbers and follicle ratios at birth, 2 and 12 weeks of age

Character		Age (wks.)	Treatment					S.E.	
			H/-	v.	L/-	-/H	v.		-/L
Density (No./mm ²)	Pf	0	18.6		20.0	17.4	21.3*	± 1.54	
		2	14.1		16.3	12.9	17.5**	± 1.14	
		12	5.8		5.7	5.4	6.1	± 0.52	
	Sf	0	64.6		49.6	65.1	49.0*	± 6.51	
		2	66.2		53.5	68.6	51.2	± 9.92	
		12	69.7		62.3	67.0	65.0	± 6.83	
	Pf + Sf	0	83.3		70.0*	83.0	70.3*	± 5.57	
		2	79.9		69.9	81.1	73.7	± 9.74	
		12	75.4		57.5	66.9	66.0	± 7.09	
	Population (No.x10 ⁶)	Pf	0	3.6		3.5	3.8	3.3*	± 0.22
			2	3.3		3.2	3.3	3.2	± 0.26
			12	3.7		3.2	3.5	3.4	± 0.31
Sf		0	12.7		9.6*	14.3	8.0***	± 1.41	
		2	15.8		11.7	17.6	10.0*	± 2.61	
		12	44.5		36.2	44.2	36.5	± 4.79	
Pf + Sf		0	16.4		13.1*	18.2	11.3***	± 1.40	
		2	19.2		14.9	20.8	13.2*	± 2.69	
		12	48.2		39.4	47.7	39.9	± 4.96	
Sf/Pf	0	3.5		2.8	3.8	2.0*	± 0.48		
	2	4.8		3.9	5.5	3.1**	± 0.73		
	12	12.2		11.2	13.0	10.4	± 1.24		

Note:

- Pf = mature primary follicles
 Sf = mature secondary follicles
 * P<0.05
 ** P<0.01
 *** P<0.001

Clean wool production of -/H lambs was greater than in -/L lambs from birth to 12 weeks of age, and from 12 to 20 weeks of age.

IV. DISCUSSION

An outstanding feature of these results was the recuperative capacity of -/L lambs in early postnatal life with respect to body weight and wool growth. This degree of compensation would be unlikely in lambs reared by their dams, with an impaired lactational performance. LL lambs, however, were still considerably smaller at 20 weeks of age than their fellows. It remains to be seen whether there is any permanent reduction in adult body size and wool production such as that found by Schinckel and Short (1961) as a result of prenatal under-nutrition.

The performance of LH lambs did not differ appreciably from that of HH lambs. However, two considerations prevent the unequivocal conclusion that

TABLE 3

Mean wool production

Character	Interval (wk)	Treatment				S.E.
		H/-	v. L/-	-/H	v. -/L	
Clean wool production per unit area (mg/cm ²)	Before birth	0.653	0.653	0.730	0.576**	± 0.488
	Birth-12	73.9	67.8	74.4	67.4	± 7.84
	12-20	73.4	69.9	70.8	72.5	± 4.52
Estimated total clean wool production (g)	Before birth	13.0	12.9	16.1	9.8***	± 1.30
	Birth-12	329	265	340	254*	± 31.6
	12-20	363	335	362	338	± 22.8

severe maternal undernutrition in early pregnancy, followed by abundant feeding, is consistent with optimal postnatal lamb performance. The LH lambs which were artificially reared may have represented an atypical sample of the original population due, firstly, to the loss of LH foetuses through abortion and, secondly, to the selection policy operating at birth.

McClymont and Lambourne (1958) found that low planes of maternal nutrition up to four weeks before lambing had an appreciable adverse effect on the birth weight and body weight gains of lambs reared to six weeks of age. The present results show that retarded placental development and foetal growth at 90 days of gestation resulting from maternal undernutrition (Everitt 1964) may be compensated under a -/H feeding regime from 90 days to lambing. Prolongation of the underfeeding period past 90 days reduces the time available for re-feeding and may also impair the efficiency of the compensatory process.

The marked differences in body conformation of lambs at the same age were shown to be largely due to differences in body weight. This suggests that the primary effect of undernutrition was a reduced body mass, and that body conformation was primarily a function of mass. The apparent differential effect of undernutrition on the various dimensions at birth (Figure 4) can be explained on the basis that, at birth, the -/L lambs were developmentally 15 days younger than the -/H animals, the anatomical age being estimated from the curves of cloete (1939). Leg length, an "early maturing" character on an age basis, was notably short in LL lambs at 6 kg body weight, but at the heaviest body weight compared (16 kg) the various body dimensions were much the same for all groups.

Although immature secondary wool follicles were not counted, the results for mature follicles are in general agreement with those of other workers. Schinckel and Short (1961), for example, found that gross underfeeding throughout pregnancy reduced the Sf population and the Sf/Pf ratio at birth. In this study, severe undernutrition both before and after 90 days of pregnancy, caused a significant reduction in both Sf population and Sf/Pf ratio. As S initiation takes place after about 90 days of -gestation (reviewed Fraser and Short 1960), the recorded reduction in Sf population was possibly due to a residual effect of early undernutrition on foetal growth generally, and S maturation in particular. By 12 weeks of age the -/L lambs had partially compensated for the reduced prenatal maturation of S follicles.

The -/L lambs had lighter birthcoats than -/H lambs in terms of both weight per unit area and estimated total birthcoat. Alexander (1962) has suggested that insulation of birthcoat may be important for neonatal survival under cold, wet, windy conditions. A reduced birthcoat may aggravate other disadvantages of -/L lambs.

While the estimated birthcoat of -/L lambs was 62% of the -/H, estimated clean wool production between birth and 12 weeks of age was 75 % , and between 12 and 20 weeks was 93%. This indicates that prenatal influences on wool production had been substantially overcome by 20 weeks of postnatal life.

V. ACKNOWLEDGMENTS

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