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THE EFFECT OF TWO DIFFERENT PLANES OF NUTRITION FROM CONCEPTION TO FOUR YEARS OF AGE ON THE MAINTENANCE REQUIREMENTS AND ON THE EFFICIENCY OF WOOL GROWTH

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SUMMARY

Mature sheep which had had a previous history of continuous undernutrition from conception to 4½ years of age (L) produced less wool than sheep well nourished throughout life (H), whether fed at the same level per unit liveweight $^{0.73}$ or fed *ad libitum*. However, the maintenance requirements of the two groups of sheep were similar.

When feed was offered *ad libitum*, the L sheep, which were much smaller at the start of the experiment, had intakes similar to the H sheep, gained more weight, but produced less wool than the H sheep. Efficiencies of wool growth were similar when intakes were restricted, but in animals fed *ad libitum* there was a suggestion that the L sheep were less efficient than the H sheep.

THE level of nutrition at which sheep are reared can have a profound effect on their subsequent productivity. In experiments described in the literature (*e.g.*, Henderson, 1953; Coop and Clark, 1955; Schinckel and Short, 1961; Reardon and Lambourne, 1966), the nutritional treatment was imposed on the animals in the first year of life. Once the treatment had been discontinued, at least some compensatory growth occurred so that at maturity only small differences in liveweight were present between groups.

The animals used in the present study had been exposed to two widely different planes of nutrition from conception to 4½ years of age. They were obtained from a project initiated in 1953 at the Whatawhata Hill Country Research Station by I. J. Inkster, to study the effects of two planes of nutrition on the lifetime production of New Zealand Romney ewes under hill country conditions. Two flocks, each of 200 mixed-aged ewes, were used. The sheep were managed in such a way that there was an average difference in liveweight of 11 to 16 kg between the means of the two flocks. The flocks were kept genetically similar by interchanging rams at fortnightly intervals

TABLE 1: MEAN PRE-MATING LIVEWEIGHTS, FLEECE WEIGHTS, PERCENTAGE DRY EWES AND PERCENTAGE LAMBS BORN IN THE HIGH AND LOW PLANE FLOCKS

(Data for 1961–5)

	Flock High	*Flock* Low
Pre-mating wt (kg)	48	35
Fleece wt (kg)	3.8	2.5
Dry ewes (%)	7.6	16.8
Lambs born (%)	106	82

TABLE 2: MEAN PRE-MATING LIVEWEIGHTS, FLEECE WEIGHTS, PERCENTAGE DRY EWES AND PERCENTAGE LAMBS BORN IN THE FAT LAMB FLOCK

(Data for 1961–5)

	Flock of Origin			
	High		*Low*	
	Age of Ewes (yr)			
	5	*6 to 9*	5	*6 to 9*
Pre-mating wt (kg)	52	50	41	46
Fleece wt (kg)	3.8	3.1	3.5	2.9
Dry ewes (%)	9.9	18.6	14.5	16.7
Lambs born (%)	110	99.5	90	97.5

during mating. Ewes from both flocks were cast-for-age at 4½ years of age. They were then run together under easier conditions for fat lamb production until they died. Some of the vital statistics of the two flocks, are shown in Tables 1 and 2.

Table 1 shows the pre-mating weights, fleece weights, percentage dry ewes and percentage lambs born of two-tooth to four-year-old ewes mated in the two flocks during 1961–5. inclusive. It is obvious that the nutritional treatments produced large differences both in wool production and in reproductive performance.

The performance of five-year-old and of six- to nine-year-old ewes when the sheep from the two flocks were run together is shown in Table 2. The reproductive superiority of the large sheep disappeared after the first year in the fat lamb flock but they continued to produce 0.2 kg more wool per year than the smaller sheep in the later years. Feed intakes were not measured in Inkster's experiment, hence no information was available on the maintenance requirements and efficiency of wool growth of the sheep in the two flocks.

The original project was terminated in 1965, but nucleus flocks were kept for detailed studies. This paper presents the results of the first portion of these studies. It was designed to compare:

(1) The maintenance requirements;

(2) Wool growth on restricted and unrestricted levels of feed intake;

(3) Efficiency of wool growth on restricted and unrestricted levels of intake of mature sheep from the two flocks.

The animals used in the present study had been exposed to widely differing nutritional treatments throughout their life. How had the difference in nutrition affected their maintenance requirements? How much would they eat when intake was unrestricted? How much wool would they produce on restricted and unrestricted intake? How efficient was their wool production? Had undernutrition during the time of follicle development placed a ceiling on wool productivity and efficiency? These questions were of interest to the investigators *per se.* To the New Zealand farmer, they are of practical interest since he is faced with buying cast-for-age ewes with an obvious lifetime difference in nutrition. Results from Inkster's experiment answered some of the questions; this paper reports on others.

MATERIALS AND METHODS

ANIMALS

The 32 sheep used in this experiment consisted of sixteen 4½-year-old high plane ewes and sixteen 4½-year-old low plane ewes, selected at random from within the two flocks. These groups will be referred to as the H and L ewes, respectively.

NUTRITION

The sheep were placed in individual indoor pens on March 23, 1966. They were individually fed a pelleted ration (50% lucerne—50% maize) at a level of 55 g/kg $W^{0.73}$* until May 4, 1966. On that date, the two groups of

*The liveweights used in calculating daily rations were of the ewes on January 19, 1966.

ewes were each divided in half (randomization being restricted on a liveweight basis) and the different nutritional treatments began.

Period 1

The groups were fed as follows for 16 weeks:

H ewes fed *ad libitum* (HA group).
H ewes at a restricted plane of nutrition, 55 g/kg $W^{0.73}$/day (HR group).
L ewes fed *ad libitum* (LA group).
L ewes at a restricted plane of nutrition, 55 g/kg $W^{0.73}$/day (LR group).

On August 26, the HA and LA groups were killed.

Period 2

The HR and LR groups were fed for a further 16 weeks at 45 g/kg $W^{0.73}$/day. These ewes were killed on December 16.

DATA COLLECTED

Feed Intake and Liveweight

All sheep were individually fed once daily. There were no residues from the HR and LR groups during either period. The HA and LA groups were fed at a level approximately 10% above the previous day's intake. Residues were collected once a week and dried at 105°C. All feed intakes are expressed as grams of dry matter.

Digestibility trials were carried out with four wethers at each of the three feeding levels. The sheep were weighed weekly.

Wool

All sheep were shorn at the beginning and the end of each experimental period—*i.e.*, on May 4 and August 24. The HR and LR groups were shorn again on December 14.

Carcass

At slaughter, hot carcass weight, weight of stomach both full and empty, weight of intestine plus contents and weight of liver were recorded. The left fore cannon bones were collected, cleaned and air-dried before weighing and measuring lengths. The carcasses were frozen

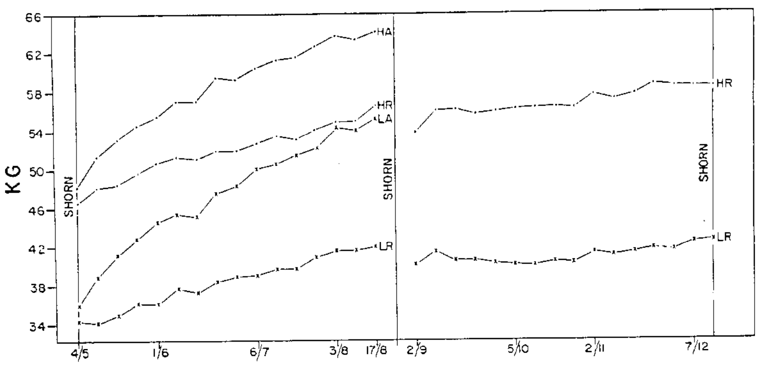

Fig. 1: Mean liveweights of high (H) or low (L) plane ewes on restricted (R) or unrestricted (A) intakes.

and duplicate water, fat and protein determinations were carried out by the technique of Kirton *et al.*, (1962).

RESULTS

LIVEWEIGHTS

Figure 1 shows mean liveweights (adjusted for wool growth) of the four groups of ewes during both experimental periods.

Restricted Groups

It is obvious that during period 1, the groups on restricted intake were fed considerably above maintenance, gaining approximately 9 kg in the 16 weeks. During period 2, however, they gained less than 3 kg. Thus the ration of 45 g/kg $W^{0.73}$ fed during period 2 approximated maintenance requirements. The liveweight curves of the HR and LR groups were parallel during both periods which suggests that these two groups of ewes had similar maintenance requirements.

Ad libitum *Groups*

Both groups gained a considerable amount of weight with the LA group showing a significantly greater gain than the HA group.

FOOD INTAKES

Table 3 presents data on the liveweights and intakes of ewes fed *ad libitum*. Expression of these data for intake per unit of initial L.W.$^{0.73}$ showed that highly significant differences between groups were present. The LA group consumed 32.3% more food per unit initial L.W.$^{0.73}$ than the HA group. The digestibility of the ration was 67.5%, 72.5% and 76.5% when fed *ad libitum*, at 55 g/kg W$^{0.73}$ and at 45 g/kg W$^{0.73}$, respectively.

TABLE 3: LIVEWEIGHT AND INTAKE DATA OF THE EWES FED *Ad Libitum*

Group	*Liveweight (kg) Initial*	*Liveweight (kg) Gain*	*Total Intake (kg)*	*Daily Intake (g) / Initial L.W.$^{0.73}$ (kg)*
HA	48.2	15.9	144.2	76.1
LA	35.8	19.5	153.7	100.7
Signif. of Diff.	***	*	NS	***

NS: $P>0.05$; $^{*}P<0.05$; $^{***}P<0.001$.

TABLE 4: MEAN FLEECE WEIGHTS AND EFFICIENCY OF WOOL GROWTH FOR EWES FED *Ad Libitum* OR A RESTRICTED DIET

Group	*Fleece Wt (kg)*	*Signif. of Diff.*	*Fleece Wt / Intake*
HA	1.92	NS	0.0134
LA	1.68		0.0110
HR—Period 1	1.77	***	0.0170
LR—Period 1	1.42		0.0176
HR—Period 2	1.66	***	0.0199
LR—Period 2	1.37		0.0211

NS: $P>0.05$; $^{***}P<0.001$.

WOOL PRODUCTION

The mean fleece weights and efficiencies of wool production determined during the experimental periods are given in Table 4.

Although the H ewes grew more wool than the L ewes, both on restricted and unrestricted intakes, the differences were statistically significant between the restricted groups only. Adjustment of the data by covariance for variation in liveweight revealed that no significant differences in wool production existed between the groups. Thus the LA group of ewes consumed 32.3% more food per unit of L.W.$^{0.73}$, gained 22.6% more weight, but produced 12.5% less wool than the HA group.

Examination of the data for fleece weight relative to feed intake (Table 4) showed that during period 1 the HA ewes were more efficient than the LA ewes, while the HR and LR animals had similar efficiencies giving rise to a significant interaction ($P<0.05$). During period 2, the HR and LR groups also had similar efficiencies.

Carcass Data

The groups of ewes on restricted and unrestricted diets were killed at different times and comparison of the resulting slaughter data must be made with caution. However, it was clear that the carcass weights reflected the different liveweights of the four groups. The cannon bones of the H groups were significantly heavier

TABLE 5: WEIGHTS (G) OF ORGANS FROM EWES FED *Ad Libitum* OR A RESTRICTED DIET

Group	*Empty Stomach*	*Stomach Contents*	*Intestine + Contents*	*Liver*
HR	1,320	3,161	3,011	621
LR	1,108	3,797	2,398	506
Signif. of Diff.	***	NS	**	**
HA	1,571	3,371	3,118	1,018
LA	1,426	2,749	3,378	1,059
Signif. of Diff.	NS	NS	NS	NS

NS: $P>0.05$; $^{**}P<0.01$; $^{***}P<0.001$.

TABLE 6: PERCENTAGES OF FAT, PROTEIN AND WATER IN CARCASSES OF EWES FED *Ad Libitum* OR A RESTICTED DIET

Group	*Fat*	*Protein*	*Water*
HR	43.4	12.3	40.4
LR	35.0	13.9	46.3
Signif. of Diff.	**	**	**
HA	46.0	11.9	38.6
LA	47.0	11.5	39.4
Signif. of Diff.	NS	NS	NS

NS: $P>0.05$; $^{**}P<0.01$.

and longer ($P<0.01$) than those of the L groups. This implies that the H sheep were the larger boned animals.

Table 5 shows that on restricted feed intake, the LR group had smaller stomachs, intestines and livers than the HR group. However, when intake was not restricted, there were no significant differences between the two groups in the weights of these organs. This suggests that feed intake and therefore productivity of the L sheep was not restricted by the size of their alimentary tracts.

The data on carcass composition given in Table 6 show that when restricted in dry matter intake, the LR sheep had a lower percentage of fat and a higher percentage of water and protein. These differences were significant ($P<0.01$). In contrast, in the sheep fed *ad libitum*, there were no significant differences in carcass composition between the H and L animals. Thus, the data on carcass composition support the intake and liveweight data, namely that the L sheep were initially thinner animals, but, since they ate relatively more, they put on more fat when fed *ad libitum*.

DISCUSSION

The lower wool production of the low-plane sheep, even on unrestricted feeding, suggests that undernutrition, probably in early life, had put a ceiling on wool production, either by a reduction in fibre numbers or by limiting the productivity of individual follicles.

These data are from sheep fed in indoor pens and caution is necessary if extrapolating to animals under grazing conditions. Neither the data of Inkster (unpubl.) nor the present data give information on sheep production per acre as distinct from production per unit of feed intake or per unit liveweight. With this proviso in mind, the practical implications of these findings, added to Inkster's data on reproductive performance, can be summarized:

Sheep subjected to a low plane of nutrition until 4½ years of age will, when compared to animals fed at a high plane of nutrition till a similar age, and run under New Zealand conditions of fat lamb farming, produce fewer lambs as 5-year-olds, but thereafter will produce a similar number of lambs. The low plane animals will produce less wool at all ages but efficiencies of wool production will be comparable except perhaps when intakes are not restricted. Under conditions of maximum productivity per acre, unrestricted feeding seldom occurs, and profitability of buying well- or poorly-grown cast-for-age ewes will depend on economic factors such as the price differential between the two classes of animals.

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