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THE EFFECT ON WOOL GROWTH IN THE NEW ZEALAND ROMNEY OF DIETARY SUPPLEMENTS OF NORMAL AND TREATED CASEIN

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(With four text figures)

ABSTRACT

An experiment was conducted to determine the effect of chemically treated casein supplements on winter wool growth. All sheep were housed in individual pens and fed a basic diet of chopped hay and oat grain at two levels—half the sheep received a maintenance ration calculated on body weight, and the other half received a half-maintenance ration. Within each of these two groups, a further subdivision was effected. One group received 30 g of untreated casein, one group 60 g of untreated casein, a third group was fed 30 g of treated casein and the fourth group received 60 g of treated casein per day. This situation was similar at both levels of basic diet.

All sheep were weighed each week and their weights were recorded. Small but positive increases in body weight were noted, and the relationship between casein and this increase is discussed.

A comparison of treated versus untreated casein was made each month for five months, commencing in April 1968, and concluding in September 1968, and this comparison was considered in terms of wool weight, fibre length and fibre diameter. Similarly, a study of energy levels and treatment of casein was made and the significance of these results are discussed.

INTRODUCTION

The rate of production of keratinised fibres from skin follicles in sheep can be profoundly influenced by nutrition. Some of the earliest controlled experiments demonstrating this fact appear to be those reported by Weber (1931) and Fraser and Nichols (1934). Although there were other reports in the literature which suggested that wool growth was probably affected by nutritional factors, these were concerned with observations of seasonal variations in wool growth of grazing animals (Lush and Jones, 1923); Duerden and Bosman, 1927; Hardy and Tennyson, 1930; Burns, 1931).

During the late 1920s and early 1930s a substantial controversy developed around the problem of whether or not the sheep could synthesise cysteine (Marston and Robertson, 1928; Barritt and King, 1926, 1929; Rimington, 1929; Rimington and Bekker, 1932; Pollard and Chibnall, 1934). At this time, because of the relatively large amount found in wool, cysteine was regarded as an essential amino acid for wool growth. An increase in wool growth due to a supplement of blood meal fed to grazing sheep was inferred by Marston (1932) to be due to the intake of cystine contained in the blood meal. He also attributed the superiority of a supplement of yeast as compared with casein for wool growth to the higher cystine content of yeast. The first reported response of wool growth to the administration of a sulphur containing amino acid was given by Marston (1935). The biological significance of methionine was not known at this time.

Under normal circumstances, ruminants make inefficient use of high protein diets. It has been shown that some proteins are readily degraded by rumen micro-organisms to ammonia, a large part of which may then be absorbed and excreted as urea. When dietary protein content is high, the extent of protein degradation probably exceeds protein synthesis by rumen micro-organisms (McDonald, 1948). Thus substantial amounts of dietary protein may be lost to the animal. Considerable losses of nitrogen due to ammonia production in the rumen have been demonstrated with protein-rich meals and soluble proteins such as casein (McDonald, 1952; Annison, *et al.*, 1954; Chalmers and Synge, 1954). However, nitrogen retention and conversion to animal products such as wool are enhanced when proteins are administered directly into the abomasum or duodenum (Chalmers, *et al.*, 1954; Reis and Schinckel, 1963, 1964).

The latest development in the administration of protein into the abomasum or duodenum is to use protein protected from rumen microbial degradation by chemical modification (McDonald, 1967). Any protection procedure would need to leave the protein in a form capable of digestion and absorption further along the alimentary tract so that the protein could be utilised. The pH differential between the rumen, normally above pH6, and the abomasum, normally below pH3, allows scope for reversal of the effects of coating or chemical treatments.

Sheep produce wool at the maximal rate of which they are capable for only a brief period in each

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year (Williams and Schinckel, 1962). Under New Zealand conditions Romney sheep produce three times as much wool during the the maximal period as in the minimal period (Story and Ross, 1960). This leads to tender wool, and often a break in the staple which results in increased fibre breakage during processing, particularly in combing. Some of this difference can be accounted for by nutrition, and so using pen fed sheep, this experiment set out to find whether the trough of wool growth during the minimal period could be partially or completely eliminated by supplementing the basic diet with casein protected from rumen microbial degradation.

MATERIALS AND METHODS

1. Plan of Experment

The plan provided for eight groups each of five sheep. Two different levels of basic ration were used, maintenance and half maintenance, and superimposed on these was the feeding of two kinds of casein, each at two levels. The eight groups are shown in Table I.

TABLE I—OVERALL PLAN OF EXPERIMENT

0.5 Maintenance (159 g chaffed hay—272 g whole oats/day)

Supplement	*Name of Group*
+30 g casein/day	0.5M/C30
+60 g casein/day	0.5M/C60
+30 g treated casein/day	0.5M/TC30
+60 g treated casein/day	0.5M/TC60

1.0 Maintenance (318 g chaffed hay—545 g whole oats/day)

Supplement	*Name of Group*
+30 g casein/day	1.0M/C30
+60 g casein/day	1.0M/C60
+30 g treated casein/day	1.0M/TC30
+60 g treated casein/day	1.0M/TC60

2. Experimental Sheep

(a) Selection of Sheep

The experimental sheep were five-year-old Romney ewes that had been retained in a commercial flock. All ewes had lambed and reared a lamb or lambs in the four previous years. Forty were selected mainly on the basis of body size and similar wool type and were identifiable by ear tag. The forty selected were allocated at random to the eight groups shown in Table I.

The intention was that experimental work should not be complicated by pregnancy and lactation and reasonable steps were taken to keep the experimental ewes segregated prior to the commencement of feeding regimes. However, as the experiment progressed, it became apparent that some of the ewes were pregnant, and pregnancy toxaemia in some provided an added complication. The best that could be done was to remove lambs from those ewes that lambed, within forty-eight hours of birth. It would be wrong to assume that pregnancy had no effect on wool production but this effect is likely to have been small. Pregnancy is not by any means the major cause of low winter production since the seasonal rhythm of wool production is obvious in dry ewes (Ferguson, *et al.*, 1949) and in both dry ewes and lambs (Coop, 1953). However, pregnancy and lactation together have a strong influence on seasonal differences in wool production (Bosman, 1935; Jones, *et al.*, 1944).

(b) General Management of Sheep

On 30 April 1968, all sheep were allotted at random to individual pens. They had free access to water at all times and were fed daily in the mornings.

Because of the well-known lag in attainment of equilibrium in wool production following change in nutritional level (Marston, 1948), management was divided into two phases, pre-experimental and experimental. The former lasted one month and the latter four months. Calculation of maintenance diets was made on the basis of W 0.73 where W is the body weight of the sheep in Kg. Sheep were fed the amounts as calculated by Coop (1962).

TABLE II—MAINTENANCE RATIONS FED TO SHEEP OF VARYING WEIGHTS

Live Weight (Kg)	*Maintenance Ration* Kg DOM/day
54.5	0.48
63.6	0.54
72.7	0.58

3. Measurement of Wool Growth

At the commencement of the trial the sites for wool sampling were delineated on each sheep. The square of 100 cm^2 was positioned on the right side of the backbone approximately one hand span ventrally, with the rear margins of the 100 cm^2 area over the last rib. This region of the side is in common use in fleece sampling and is referred to as 'mid-side' (Turner, 1956).

Wool clipped from the right 'mid-side' area every twenty-eight days was used for the determination of clean wool production. The wool was removed from the area with an 'Oster' electric clipper using a clipping head number 50, and size 000.

The five samplings over the course of the investigation are given in Table III.

TABLE III—WOOL SAMPLING PERIODS

Sample Number	*Date of Clipping*	*Growth Period*
1. Pre-experimental	28.5.68	1.5.68–28.5.68
2. Experimental	25.6.68	29.5.68–25.6.68
3. Experimental	23.7.68	26.6.68–23.7.68
4. Experimental	20.8.68	24.7.68–20.8.68
5. Experimental	17.9.68	21.8.68–17.9.68

Each 'mid-side' sample of wool was weighed and recorded as clean dry wool.

4. Measurement of Fibre Length

The fibres from the twenty-eight-day clippings were too short for any of the conventional fibre length measurement techniques to be used. A projection method was developed based on the suggestion of Chapman (1960). Random subsamples of approximately 100 fibres were mounted on cellulose adhesive tape fixed to 2" x 2" glass slides. A suitable refraction was thus provided by the air layer 'trapped' around each fibre.

The fibre images were projected through a standard air cooled slide projector with a 45° mirror suspended in front and supported at a suitable height to provide an image magnification of 10 x upon the bench below. Measurements across the projected field revealed no significant error due to optical aberration.

5. Measurement of Fibre Diameter

The projection microscope method is generally accepted as the most accurate technique for determining fibre diameter (Anderson and Palmer, 1948, 1951a, 1951b; Palmer, 1951; I.W.T.O., 1952; Anderson and Benson, 1953; British Standards, 1953; American Society for Testing Materials, 1961; Kritzinger, Linhart and Van der Westhuyen, 1964). Short fibre lengths from a random subsample were mounted in Canada balsam on a 3" x 1" microscope slide and projected at 500 x magnification (1 mm on image=2 microns). The diameters of 250 fibres were measured and recorded.

6. Statistical Treatment of Data

The experiment was designed to have five replications of eight treatments arranged in a 2 x 2 x 2 factorial design. Data were dealt with by analysis of variance, and 'Student's' t-distribution test was applied to each individual treatment within the analysis of variance. The significance level and minimum difference required for significance were calculated and applied to the data.

RESULTS

1. The Effect of Level of Basic Ration and of Casein Supplementation on Body Weght

Mean body weights for all groups except 0.5M/C60 and 1.0M/TC30 were complicated by pregnant sheep within the groups. Fig. 1 represents the adjusted body weights making allowance for pregnancy.

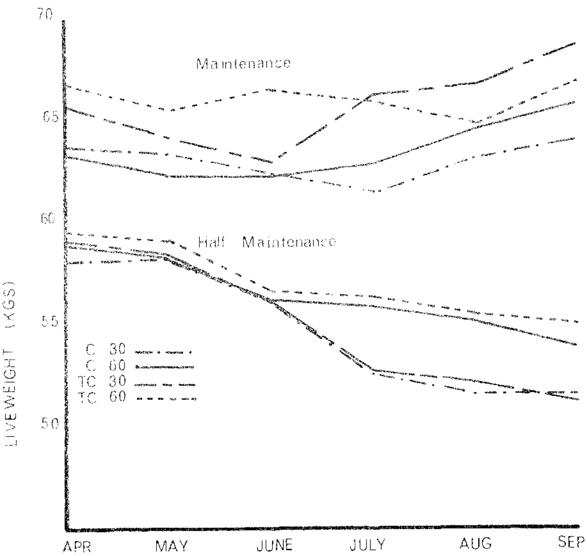

FIG. 1 Adjusted Group Mean Liveweights

As expected all sheep in the half-maintenance energy group lost weight, but during the last two months of the trial their weights remained relatively constant. Sheep on maintenance energy rations all gained small but positive amounts in body weight during the experimental period.

2. The Effect of Level of Basic Ration and Casein Supplementation on Weight of Wool Grown

Group mean weight of wool grown throughout the pre-experimental and experimental periods is given in Fig. 2 (*a*) and (*b*).

At no stage during the experimental period was there any significant difference between 30 g/day and 60 g/day of the casein (Table IV), although significance was approached during the last three months of the trial.

The energy level of the ration, as expected, was highly significant in terms of weight of wool grown for the last three periods of the trial. The fact that there was no significant difference for the first of the experimental periods is possibly due to the carry-over effect from the pre-experimental period.

3. The Effect of Level of Basic Ration and Casein Supplementation on Fibre Diameter

Group mean measurements of fibre diameter throughout the pre-experimental and experimental periods are given in Fig. 3 (*a*) and (*b*).

From the results given in Table V, the level of casein in the ration (i.e., 30 g/day *v* 60 g/day) was significant for the periods 29 May to 25 June 26 June to 23 July and 24 July to 20 August inclusive. For the rest of the trial the level of casein was not significant.

The energy level in the ration (i.e., 0.5M *v* 1.0M) had a significant effect on fibre diameter during the periods 26 June to 23 July and 24 July to 20 August only. Significance was approached in the last period.

Treatment of casein with formalin had a significant effect on fibre diameter during the periods 26 June to 23 July and 24 July to 20 August. However, the complication of pregnancy could have been a major contributing factor in the low level of significance since all sheep lambed in the period 24 July to 20 August, and fibre diameter readings for this period are likely to be unrealistic.

4. The Effect of Level of Basic Ration and Casein Supplementation on Fibre Length

Group mean measurements of fibre length throughout the pre-experimental and experimental periods are given in Fig. 4 (*a*) and (*b*).

From the results in Table VI, the level of casein in the ration is significant only in the periods 29 May to 25 June, and 21 August to 17 September. In the two intervening periods significance is approached. Once again, the complication caused by pregnancy in this period could be a contributing factor.

The energy level in terms of fibre length is only significant in the periods 29 May to 25 June and 26 June to 23 July. During the period in which all sheep lambed, that is 24 July to 20 August, the pregnancy factor may have been more of a complication than was first thought.

Treatment of casein in the ration showed a significant response for all months of the experimental period except 26 June to 23 July.

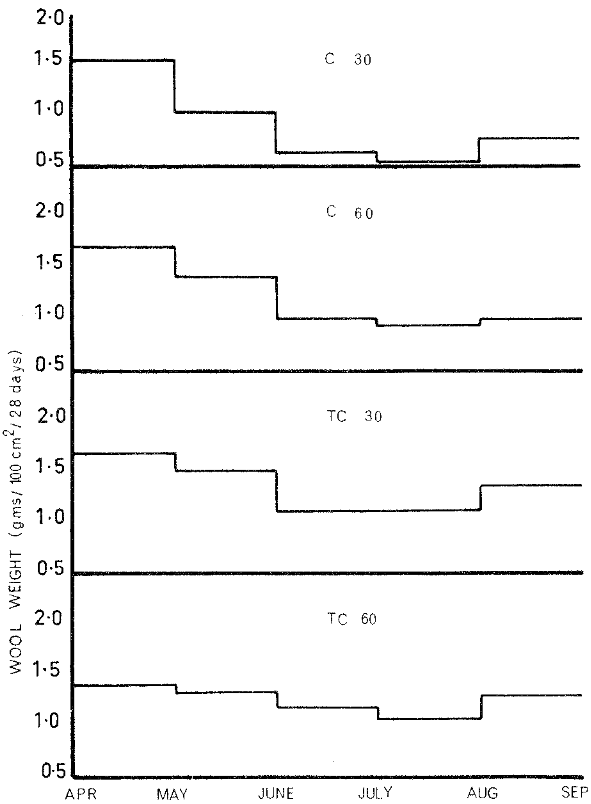

FIG. 2(a) Group Mean Wool Weights (Half Maint.)

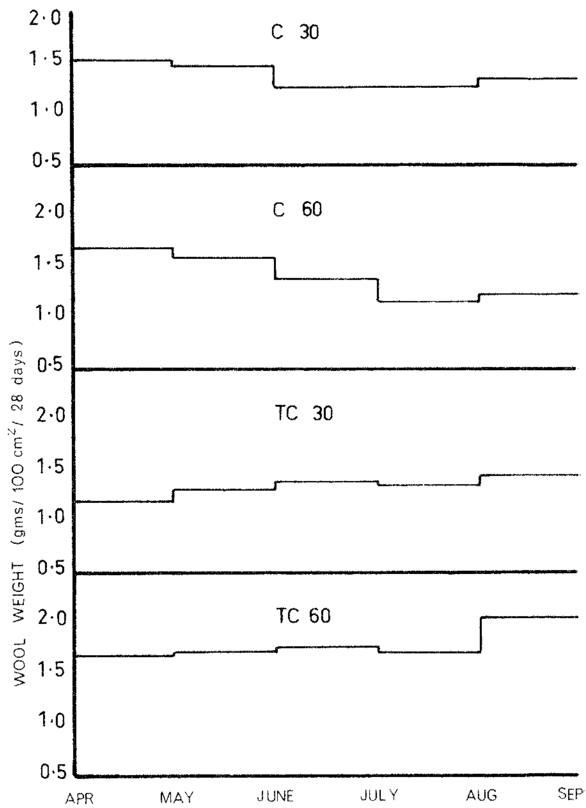

FIG. 2(b) Group Mean Wool Weights (Maint.)

DISCUSSION

The increase in the rate of wool growth obtained in this experiment when casein, chemically treated with formalin, was fed, is in agreement with the results of Reis and Schinckel (1961, 1963). The extra energy available from the casein was far too small to account for the increases in wool growth which were obtained. A similar untreated supplement may not result in increased wool growth when added to the diet and exposed to ruminal activity, and this is borne out in the results of those sheep receiving untreated casein. This agrees with the lack of wool growth response to levels of dietary protein above 8% in the experiments reported by Ferguson (1959). It thus appears that protein, apart from its energy value, can specifically stimulate wool growth and that the S-amino acids may be especially important. However, the specific function of cysteine in stimulating wool growth is not known at present.

Although cysteine and methionine are present in the form of S-amino acids, their exact amounts are not known. The mechanism of action of these two S-amino acid supplements in stimulating wool growth is obscure but several possibilities exist (Reis and Schinckel, 1963). There may be some general anabolic effect which indirectly affects keratin synthesis in the follicles. There is an indication of such a general anabolic effect because there was a positive increase in body weight in all sheep receiving a maintenance energy ration plus casein, but not affected by pregnancy. There may also be direct effects on keratin synthesis in the follicle. Cysteine may be the limiting amino acid for keratin synthesis as suggested by Marston (1935, 1948, 1955) and the feeding of casein may simply increase the supply of substrate available for keratin synthesis. There may also be some other specific effect of cysteine or of the sulphur or sulphydryl component of the molecule, in the

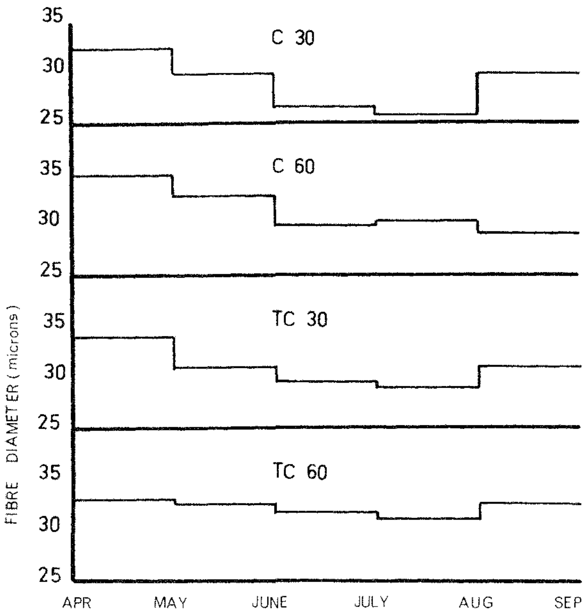

FIG. 3(a) Group Mean Fibre Diameters (Half Maint.)

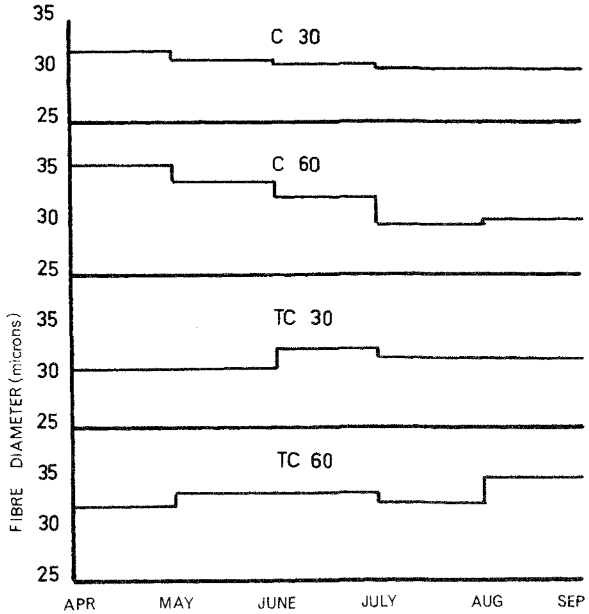

FIG. 3(b) Group Mean Fibre Diameters (Maint.)

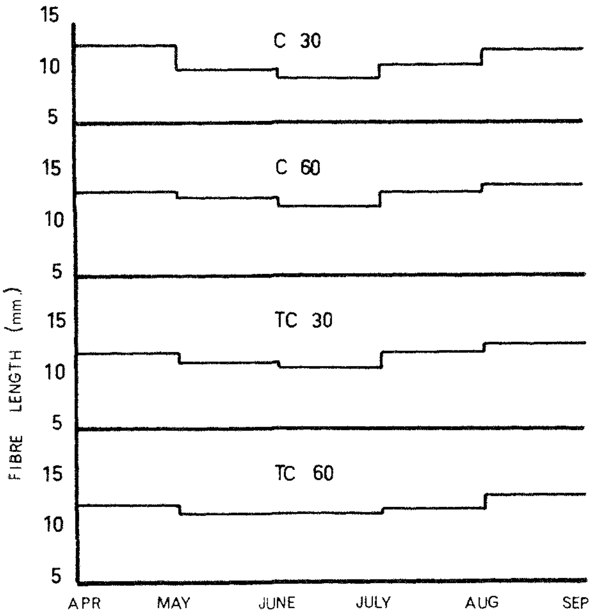

FIG. 4(a) Group Mean Fibre Length (Half Maint.)

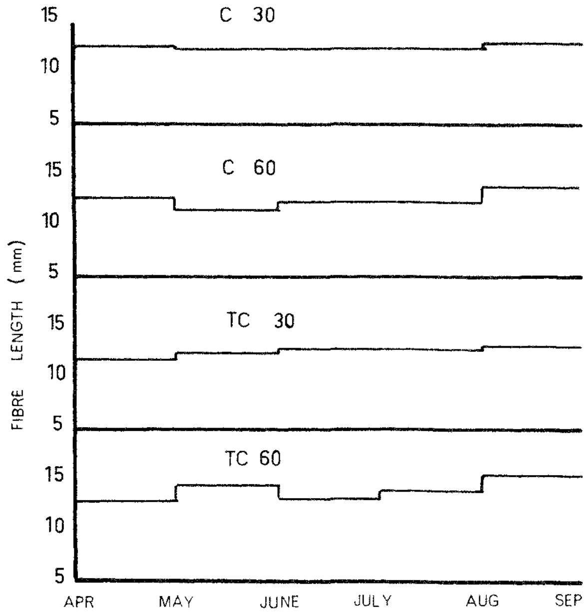

FIG. 4 b Group Mean Fibre Length (Maint.)

TABLE IV—THE EFFECT ON WEIGHT OF WOOL GROWN OF LEVEL OF CASEIN IN THE RATION (30 g/DAY *v* 60 g/DAY), ENERGY LEVEL OF RATION (0.5 M *v* 1.0 M) AND TREATMENT OF CASEIN (FORMALIN TREATED *v* UNTREATED)

	Pre-experimental				Experimental					
Period	1.5.68–28.5.68		29.5.68–25.6.68		26.6.68–23.7.68		24.7.68–20.8.68		21.8.68–17.9.68	
Casein level—	*Wt (g)*	*Diff.*	*Wt (g)*	*Diff.*	*Wt (g)*	*Diff.*	*Wt (g)*	*Diff.*	*Wt (g)*	*Diff.*
30 g	1.50		1.34		1.11		1.08		1.24	
60 g	1.63	0.13§	1.53	0.19§	1.22	0.11§	1.23	0.15§	1.39	0.15§
Energy level—										
0.5 M	1.59		1.34		0.99		0.93		1.11	
1.0 M	1.54	−0.05§	1.54	0.20§	1.46	0.47‡	1.38	0.35‡	1.52	0.41‡
Casein treatment—										
Untreated	1.50		1.34		1.11		1.07		1.23	
Treated	1.63	0.13§	1.53	0.19§	1.34	0.23†	1.22	0.15§	1.39	0.16§

	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%
Minimum difference required for significance	0.21	0.30	—	0.24	0.31	—	0.16	0.21	0.28	0.18	0.24	0.32	0.18	0.24	0.33

* P <0.05; † P <0.01; ‡ P <0.001; § Not significant

TABLE V—THE EFFECT ON FIBRE DIAMETER OF LEVEL OF CASEIN IN THE RATION (30 g/DAY *v* 60 g/DAY), ENERGY LEVEL OF RATION (0.5 M *v* 1.0 M) AND TREATMENT OF CASEIN (FORMALIN TREATED *v* UNTREATED)

	PRE-EXPERIMENTAL						EXPERIMENTAL			
Period	1.5.68–28.5.68		29.5.68–25.6.68		26.6.68–23.7.68		24.7.68–20.8.68		21.8.68–17.9.68	
Casein level—	*Diam.* (μ)	*Diff.*	*Diam.* (μ)	*Diff.*	*Diam.* (μ)	*Diff.*	*Diam.* (μ)	*Diff.*	*Diam.* (μ)	*Diff.*
30 g	32.4		30.8		30.0		29.3		30.8	
60 g	34.2	1.8§	33.4	2.2*	32.1	2.1*	31.1	1.8*	31.9	1.1§
Energy level—										
0.5 M	33.7		32.7		29.5		30.1		31.7	
1.0 M	33.8	0.1§	32.5	−0.2§	32.5	3.0†	32.2	2.1*	32.9	1.2§
Casein treatment—										
Untreated	32.3		31.8		29.0		29.3		30.8	
Treated	34.1	1.8§	33.4	1.6§	32.0	3.0‡	31.1	1.8*	31.9	1.1§

	1.5.68–28.5.68			29.5.68–25.6.68			26.6.68–23.7.68			24.7.68–20.8.68			21.8.68–17.9.68		
	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%
Minimum difference required for significance	2.23	2.98	—	1.88	2.51	—	1.80	2.41	—	1.68	2.25	—	1.77	2.37	—

* P <0.05; † P <0.01; ‡ P <0.001; § Not significant

TABLE VI—THE EFFECT ON FIBRE LENGTH OF LEVEL OF CASEIN IN THE RATION (30 g/DAY *v* 60 g/DAY), ENERGY LEVEL OF RATION (0.5 M *v* 1.0 M) AND TREATMENT OF CASEIN (FORMALIN TREATED *v* UNTREATED)

	Pre-experimental				Experimental					
Period	1.5.68–28.5.68		29.5.68–25.6.68		26.6.68–23.7.68		24.7.68–20.8.68		21.8.68–17.9.68	
	Length (mm)	*Diff.*	*Length (mm)*	*Diff.*	*Length (mm)*	*Diff.*	*Length (mm)*	*Diff.*	*Length (mm)*	*Diff.*
Casein level—										
30 g	12.5		11.8		11.6		12.2		12.9	
60 g	13.0	0.5§	12.7	0.9*	12.3	0.7§	12.9	0.7§	14.2	1.3†
Energy level—										
0.5 M	12.8		11.6		11.1		13.2		13.2	
1.0 M	13.6	0.8§	12.8	1.2†	12.8	1.7‡	13.0	−0.2§	13.9	0.7§
Casein treatment—										
Untreated	12.5		11.8		12.5		12.2		12.9	
Treated	13.9	1.4§	13.7	1.9‡	12.3	−0.2§	13.9	1.7‡	15.1	2.2‡

	1.5.68–28.5.68			29.5.68–25.6.68			26.6.68–23.7.68			24.7.68–20.8.68			21.8.68–17.9.68		
	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%
Minimum difference required for significance	1.8	2.1	—	0.73	0.98	1.29	0.86	1.15	1.51	0.82	1.10	1.45	0.79	1.06	1.39

* P <0.05; † P <0.01; ‡ P <0.001; § Not significant

follicle. This effect may be a stimulation of mitotic activity in the follicle bulb since there is much evidence that sulphydryl groups play an important role in mitosis (Stern, 1959; Mazia, 1959, 1961). Also there may be increased production of co-factors important in protein or energy metabolism. Thus, cysteine is involved in the synthesis of glutathione and co-enzyme A (Reis and Schinckel, 1963).

Restriction of wool growth by poor nutrition is associated with a reduction in length and diameter of individual fibres (Daly and Carter, 1956). It was considered by Fraser (1934) that fibre diameter was more susceptible to nutritional influence than was fibre length and Galpin (1948) found that changes in length precede changes in diameter. From this she suggested that diameter is influenced less by poor nutrition than is length.

Under normal feeding regimes, Romney sheep fed a maintenance ration throughout the winter exhibit a seasonal decline in wool production. This decline is caused by a number of factors, the two most important being photoperiodic stimulus and nutrition. While the photoperiodic stimulus cannot be altered under normal circumstances, the feeding regime can be. In the present experiment sheep fed a half maintenance energy ration showed an accentuated decline in wool production and the greater proportion of this can be attributed to the fact that these sheep were in a state of negative energy balance. Feeding of treated casein in this experiment has arrested this seasonal decline of wool production and so although no great increases in wool weight due to the feeding of treated casein are apparent, when considered in terms of seasonal wool production, the differences are very real.

In this experiment, sheep receiving a maintenance energy ration plus untreated casein showed a reduction in weight of wool grown when compared with those receiving treated casein, and this reduction was accompanied by a reduction in fibre diameter only. Earlier workers suggested that change in fibre diameter was mainly due to change in the width of the medulla, but recent work (Ryder, 1956a; Henderson, 1965) has shown that changes in diameter of the fibre are accompanied by changes in the thickness of both the cortex and the medulla.

The physical basis of the length/diameter ratio has been shown by Rudall (1955) to be the dimensional structure of the follicle papilla. However, both Fraser (1964) and Henderson (1965) found that although a clear association of these dimensions was demonstrated within sheep the relationship did not hold between sheep.

The length/diameter ratio in the present investigation altered as the nutritional regime improved. In the half maintenance energy group receiving 30 g of untreated casein per day, the effect was seen as a reduction in both length and diameter, the effect on length being greater. Feeding 30 g of treated casein substantially reduced the effect on length. Short (unpublished) and Henderson (unpublished) have noted that at low levels of nutrition any change in fibre dimensions induced by nutritional regime is seen primarily as a reduction in length. In the low energy groups receiving 60 g of untreated casein per day there was less effect on fibre length than in those sheep receiving 30 g per day, and feeding 60 g of treated casein per day produced a proportionately greater effect on fibre diameter than on fibre length.

Sheep in the maintenance energy group receiving untreated casein showed the reduction in wool weight as one of reduction in fibre diameter rather than reduction in length. It was found that while a reduction in fibre diameter occurred in sheep receiving untreated casein, those receiving treated casein showed an increase in fibre diameter. There was a greater proportionate increase in diameter than in length. This agrees with the results of Schinckel (1962) and Reis and Schinckel (1964). Schinckel (1962) observed an increase of 71% in fibre cross-sectional area during casein administration per abomasum and this increase accounted for 46% of the increased wool growth. Schinckel pointed out then that there was no way of determining the relative contributions of rate of cell production and of cell volume changes in cross-sectional area and length of fibres. It is not possible to estimate accurately changes in the mitotic rate of matrix cells from measured changes in fibre output and cortical cell volume, nor to estimate changes in fibre cell volume from observed changes in mitotic rate and fibre output (Short, *et al.*, 1965).

From the wool growth figures obtained in this investigation during the last of the experimental periods it would seem that pregnancy in sheep has a more positive effect on wool growth than was first thought. This has since been shown to be significantly correct (Bryden, unpublished). In the design of the experiment, lambs were removed within forty-eight hours from those sheep which lambed on the presumption that lactation had much more effect on wool growth than did pregnancy. However, Coop (pers. comm.) has shown that any stress effect in terms of wool growth has a long carry-over effect, and so the greater effect which can show up during lactation is most likely a carry-over effect from pregnancy.

The level of casein fed during the experimental period was not a significant factor in terms of weight of wool grown. This indicates either that 30 g per day of casein is as effective as 60 g per day, or that pregnancy in some sheep masked the response. This latter explanation would appear to be the logical one since during the last experimental period the difference between 30 g and 60 g per day of treated casein was much greater than for the rest of the experimental period when some ewes in most groups were pregnant.

A significant relationship between the level of casein and fibre diameter occurred for all but the last period of the experiment whereas significance between level of casein and fibre length only occurred in two periods. This might indicate that fibre diameter is much more sensitive than fibre length to the effects of pregnancy.

A significant relationship between energy level of the ration and wool growth occurred in all but the first of the experimental periods. The fact that no significance was evident during the first period is likely to be due to a carry-over effect from the pre-experimental period. Under ordinary feeding regimes, the rate of wool growth closely follows the intake so that the greater the intake the greater the wool production. The rate of wool production at very low levels of feeding is understandably very small, but it is apparent and continues at the expense of other tissues.

The relationship between energy level and fibre length was significant during the first two months of the experimental period only, although in the final period significance was approached. Thus, the only period when any real difference was noticed was during 24 July to 20 August, the period in which all pregnant ewes lambed.

Low significant values were obtained for the relationship between energy level and fibre diameter for all periods except 26 June to 23 July. Again, these values approached significance levels and possibly the complication caused by pregnancy may have been an important factor in these results.

It is apparent in the results of this experiment that there was some sort of an interaction between the response of wool growth to administration of treated casein and time, although this cannot be definitely assessed. The magnitude of the response to casein and S-amino acid supplements will obviously depend on how nearly the wool growth rate on the basic diet approaches the genetic potential for wool growth.

In the experiments of Reis and Schinckel (1961, 1963) the intake of basic diet was kept at a moderate level so that wool growth would be well below the maximum.

Although non-significant results were apparent in some instances throughout this investigation, the fact that most approached significance would tend to indicate that the number of sheep per group, five, was not enough. The use of larger numbers per group would most likely have shown these results that approached significance to be in fact significant.

Sheep which received a maintenance ration plus a supplement of casein increased in body weight during the experimental period. This increase, although small, was positive. There seemed to be some increase in favour of those sheep receiving treated casein, regardless of level, over those sheep receiving untreated casein, although the difference was only slight.

Various studies have clearly shown that ruminants can make use of non-protein nitrogen compounds in lieu of a part of the protein intake required for growth and maintenance. The explanation seems to be that micro-organisms in the rumen can use non-protein nitrogen to build their body protein which is in turn digested in the true stomach and intestines. Lofgreen, *et al.* (1947), suggested that the quality of protein as fed in the rations of lambs may be of importance under some conditions. It seems logical to assume that if protein quality has an effect upon the nitrogen retention of lambs that it may have some similar effect upon the gains in weight in feed lot operations.

Comparing control sheep with those receiving DL-methionine or L-cysteine administered into the abomasum, Reis (1967) found that the treated sheep showed small but consistent and positive increases in body weight. In contrast to effects on wool growth there was a progressive increase in body weight with each increment of S-amino acid.

In the present study, the significance of body weight increase is difficult to ascertain, due to the complications caused by pregnancy. For sheep being fed a maintenance ration alone, body weight should remain constant to within ±1 Kg per week, and thus it may be assumed in this case that the increase was due to the supplement of casein.

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