
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

WOOL GROWTH IN RELATION TO DIETARY PROTEIN LEVEL

R. G. CARRICO* F. R. M. COCKREM† and G. A. WICKHAM
Massey University, Palmerston North

SUMMARY

In a trial studying the wool growth response to formalin-treated casein, raising the dietary crude protein level from 12% to 20% with both treated and untreated casein gave a 30% increase in wool production during the one-month treatment period and a 50% increase during the month following treatment.

In a second trial, Romney wethers from a different source from those in the earlier trial, were divided into eight groups. Different nutritional regimes were imposed according to a 4 × 2 experimental design. Four dietary protein treatments (one including casein) ranging from 10.4% to 17.2% crude protein were fed at two different levels. There were no significant differences in wool growth rate owing to protein percentage, but after a delay of one month a significant difference due to feeding level was induced. There was no evidence of a wool growth effect due to interaction between dietary crude protein percentage and the amount fed per day.

FOR many years it was assumed that increasing a sheep's dietary crude protein above about 10% would not increase wool growth rate. This assumption arose from experiments in Britain (Fraser and Roberts, 1933), Canada (Slen and Whiting, 1952) and Australia (Ferguson, 1959) in which sheep were fed diets similar in energy content but differing in protein content. More recent results have cast doubt on the general applicability of the conclusions based on these experiments. Reis and Schnickel (1961) showed a marked increase in wool growth after abomasal protein infusion and Colebrook *et al.* (1968) provided evidence that proteins from different sources differed in their ability to stimulate wool growth when used in high protein rations. Hogan and Weston (1967) indicated that the absorption of α amino nitrogen differed little between different protein treatment groups in Ferguson's experiment. It seems that microbial fermentation in the rumen was counteracting the effects of the different protein levels.

There is considerable interest in the possibility of treating proteins to reduce ruminal degradation (McDonald,

*Present address: 1131 S.E. Main, Roseburg, Oregon 97470, U.S.A.
†Present address: Forest Research Institute, Rotorua.

1967). Wool growth responses of sheep fed "treated" proteins have been studied (Ferguson *et al.*, 1967; Reis and Tunks, 1969; Barry, 1969; Henderson *et al.*, 1970). It seems necessary to have more information on the response of sheep to variation in the normal dietary protein before experiments on treated protein can be interpreted satisfactorily.

MATERIALS AND METHODS

TRIAL 1

Twelve Romney wethers (3 sheep/group) which had been previously used in an investigation into responses to intravenous cysteine infusion (Dryden *et al.*, 1969) were studied. The earlier work indicated that these sheep were capable of responding to cysteine infusion and there were also indications of a response to varying proportions of crude protein in the diet. For the duration of the trial (including 35 days pre-treatment, 28 days treatment and 10 days post-treatment) the animals were caged in outdoor pens. The treatments were:

Group 1—Control.

Group 2—100 g/day of formalin-treated casein.

Group 3—100 g/day of untreated lactic casein.

Group 4—1 g/day of methionine hydroxy analogue (MHA) mixed with 5 g/day of casein and formalin-treated in an attempt to provide a protective coating of treated casein around the MHA.

The casein and casein-MHA was given as a supplement to 270 g of barley meal which all sheep were fed at 9 a.m. and 680 g of chopped ryegrass-clover hay fed separately at 4 p.m.

The treated casein was prepared by the New Zealand Dairy Research Institute and the preparation differed from batches produced subsequently and used in later trials (Barry, 1969; Henderson *et al.*, 1970) only in the drying procedure. Both treated and untreated casein and the treated casein-MHA were tested for fermentation in bovine rumen fluid *in vitro*. Ammonia production after 24 hours was 33.5, 1.2 and 4.3 mg NH_3/100 ml, respectively (expressed as increase over value for rumen fluid alone).

Wool growth rate was determined by repeatedly sampling an area of approximately 100 sq. cm on the left midside of each animal. Clean wool weights were determined

TABLE 1: COMPOSITION OF RATIONS (D.M. BASIS) IN TRIAL 1

	Pre-treatment	*1*	*2*	*3*	*4*
Molasses	—	4.6	3.8	4.7	5.0
Lucerne	38.8	40.1	52.2	84.3	42.8
Barley straw	—	34.1	8.0	—	7.4
Barley meal	34.5	21.2	36.0	11.0	38.6
Pea hulls	26.7	—	—	—	—
Casein	—	—	—	—	6.2
	100	100	100	100	100
Crude protein %	12.8	10.4	13.1	15.5	17.2

TABLE 2: DAILY FEEDING AND MEAN INTAKE LEVELS DURING TREATMENT PERIODS

Group	*Amount Fed (g)*	*Digestible Energy (kcal/g)*	*D.E. Fed (kcal)*	*1st Period D.E. Intake (kcal)*	*2nd Period D.E. Intake (kcal)*
1L	816	2.788	2275	2098	2048
2L	726	2.948	2140	1923	1741
3L	771	2.992	2306	2020	2048
4L	680	3.290	2237	2150	2002
1H	1224	2.656	3249	2409	2643
2H	1088	2.908	3166	2708	2673
3H	1179	2.804	3306	2677	2577
4H	1043	2.935	3061	2407	2561

TABLE 3: WOOL GROWTH RESPONSES TO CASEIN AND CASEIN-MHA

Means adjusted for pre-treatment midside values (mg/cm^2/day)

Period	*Control*	*Treated Casein*	*Untreated Casein*	*Casein-MHA*	*F*
Treatment	1.05	1.37	1.35	1.06	1.80
Post-treatment	0.99	1.57	1.59	0.98	4.73*

*$P < 0.05$

TABLE 4: RESIDUAL MEAN SQUARES FROM ANALYSIS OF COVARIANCE OF MIDSIDE WOOL GROWTH DATA FROM TRIAL 2

	DF	*1st Treatment Period*	*2nd Treatment Period*	*Post-treatment Period*
Between feeding levels	1	0.093	1.016***	0.129
Between rations	3	0.088	0.044	0.077
Interaction	3	0.016	0.025	0.011
Error	16	0.046	0.066	0.087

***$P < 0.001$

after scouring with successive four-minute elutions with petroleum ether, alcohol and hot water.

TRIAL 2

Twenty-four Romney wethers, approximately 6 months old, were housed in individual pens at constant temperature (16° C) and studied during periods of four weeks pre-treatment, eight weeks treatment (two equal periods A and B), and four weeks post-treatment.

Four rations (1, 2, 3 and 4) were fed at either of two levels (H and L) according to a 4 × 2 experimental design. The composition of the rations was varied in order to get differences in protein content, and are shown in Table 1. The feeding levels of the rations and also intakes of feed derived by subtracting refusals from the amount offered are given in Table 2. Refusals occurred to a similar extent at both levels of feeding and hinder the interpretation of the data. Six other animals were used in a nitrogen balance study on rations 1, 3 and 4 at both levels of feeding. Variation in voluntary intake limit the usefulness of these data.

Wool samples obtained at the end of each four-week period were treated as in the first trial.

RESULTS

TRIAL 1

The wool growth response to the casein supplements is shown in Table 3. The treated-casein group showed an increase in wool growth in both the treatment and post-treatment periods but surprisingly the untreated-casein group demonstrated a similar response. There was no indication of any response to the treated casein-MHA mixture.

TRIAL 2

Analysis of the wool growth data from the trial failed to reveal any differences apart from those due to the level of feeding. A summary of the analysis of covariance is presented in Table 4, while Table 5 gives the adjusted means of wool growth rate for each treatment group and for the two levels of feeding. Comparison of results for sheep fed at high and low levels shows a small difference in wool production in the first month of treatment and a marked, highly significant difference in the second month of treatment. A month after treatment finished there was no significant difference due to feeding level and the difference between means was small.

TABLE 5: MIDSIDE WOOL GROWTH IN RESPONSE TO RATIONS OF DIFFERENT PROTEIN CONTENT

Group means adjusted according to the regression on pre-treatment values ($mg/cm^2/day$)

Group	1st Treatment Period		2nd Treatment Period		Post-treatment Period	
1L	1.32		0.90		1.15	
2L	1.37		1.02		1.07	
3L	1.61	1.43	1.20	1.03	1.45	1.23
4L	1.43		1.01		1.25	
1H	1.37		1.31		1.38	
2H	1.64		1.57		1.29	
3H	1.73	1.56	1.40	1.45	1.48	1.37
4H	1.48		1.51		1.34	

There were no significant differences in wool growth due to the rations or to the interaction between ration and level of feeding. Differences were slight although wool production of sheep fed the low protein ration (ration 1) was reduced, relative to other rations, during the treatment period.

Body-weight changes were in line with the wool growth results. Very highly significant differences occurred between feeding levels during both treatment periods. There was, however, a significant difference between rations during the first month of treatment, this difference being in favour of ration 1.

The nitrogen balance studies produced few data of value but did indicate high urinary nitrogen excretions on the high protein rations.

DISCUSSION

The surprising aspect of the first trial was the response to untreated lactic casein. McDonald (1952) found that the nitrogen of casein was poorly retained when fed to sheep and yet the untreated casein group gave as great a wool growth response as the treated casein group. There are many possible explanations, none entirely satisfactory.

Analysis of the free plasma amino-acids (Carrico *et al.*, unpubl.) indicated a greater assimilation of amino nitrogen in the treated casein group than in the untreated casein group which in turn was above the control group.

This probably indicates that the treated casein group were exceeding their amino acid requirements and that other factors became more important in limiting wool growth after an initial increase had been achieved.

The complete absence of response to feeding 70 g/day of lactic casein in the second trial (H4) is difficult to reconcile with the response to untreated casein in the first trial. This presumably indicates a difference in nitrogen retention between the two groups of sheep but it is difficult to explain this difference in terms of variation in the diet. In both trials the casein was fed in conjunction with a readily available source of carbohydrate in the form of barley meal. Lucerne meal and barley straw were not present in the first trial. Another possible explanation is that the casein and barley meal were fed in the absence of fibrous material in the first trial and this may have resulted in rapid passage through the rumen. If this were the case, a response to casein-MHA might also have been expected.

The results of the second trial agree with the earlier results of Ferguson (1959) and others. There was a good wool growth response to feeding rations in greater quantities and thus increasing the substrate for rumen fermentation, but there was little if any response to the inclusion of higher proportions of protein in the diet. There were indications that wool growth might have been inhibited by ration 1 (10.4% C.P.) but this is near the lower level at which Ferguson found dietary protein content to be a limiting factor. There was also an indication that the high lucerne meal diet (ration 3) might be superior to a higher protein ration in which the protein content had been raised by the addition of casein.

The lack of a carry-over response from the high level feeding contrasts with the response to protein and to cysteine infusion (Dryden *et al.*, 1969).

It appears that groups of sheep may differ substantially in their reponse to protein supplements. If this is the case, results from individual trials must be interpreted with caution. More fundamental research on the factors determining responses, particularly differences in the rumen microbial population, are indicated.

ACKNOWLEDGEMENTS

The authors wish to thank L. Hawthorne for caring for the animals, P. Sutcliffe for technical assistance, and G. Wilson for carrying out *in vitro* ammonia release tests.

The New Zealand Dairy Research Institute donated the casein and the treated casein was prepared by C. Southward of their staff. The MHA was donated by Gollin and Co. Ltd., Auckland.

REFERENCES

Barry, T. N., 1969: *Proc. N.Z. Soc. Anim. Prod., 29*: 218.
Colebrook, W. F.; Ferguson, K. A.; Hemsley, J. A.; Hogan, J. P.; Reis, P. J.; Weston, R. H., 1968: *Proc. Aust. Soc. Anim. Prod., 7*: 397.
Dryden, G. M.; Wickham, G. A.; Cockrem, F. R. M., 1969: *N.Z. Jl agric. Res., 12*: 580.
Ferguson, K. A., 1959: *Nature* (Lond.), *184*: 907.
Ferguson, K. A.;Hemsley, J. A.; Reis, P. J., 1967: *Aust. J. Sci., 30*: 215.
Fraser, A. H. H.; Roberts, J. A. F., 1933: *J. agric. Sci. Camb., 23*: 97.
Henderson, A. E.; Bryden, J. McG.; Mazzitelli, F. E.; Milligan, K. E., 1970: *Proc. N.Z. Soc. Anim. Prod., 30*: 186.
Hogan, J. P.; Weston, R. H., 1967: *Aust. J. agric. Res., 18*: 973.
McDonald, I. W., 1952: *Biochem. J., 51*: 86.
McDonald, I. W., 1967: *Wool Tech., 14* (2): 53.
Reis, P. J.; Schinckel, P. G., 1961: *Aust. J. agric. Res., 12*: 335.
Reis, P. J.; Tunks, D., 1969: *Aust. J. agric. Res., 20*: 775.
Slen, S. B.; Whiting, F., 1952: *J. Anim. Sci., 11*: 156.