The quantities of zinc, copper, manganese and iron associated with body weight gain and wool growth of young sheep

N. D. GRACE

Applied Biochemistry Division
DSIR, Palmerston North

ABSTRACT

Fifty New Zealand Romney lambs (25 wethers and 25 ewes) grazing a ryegrass/white clover pasture from weaning, were used to study the distribution of zinc, copper, manganese and iron among the various organs and tissues and the amounts associated with a kilogram gain in fleece-free empty body weight. Each kilogram gain in fleece-free empty body weight was associated with 24 mg Zn, 0.77 mg Cu, 0.47 mg Mn and 55 mg Fe, while a kilogram of clean wool contained 220 mg Zn, 7 mg Cu, 3.5 mg Mn and 23 mg Fe.

Thus for a young sheep gaining 100 g of fleece-free empty body weight/d and maintaining a mean wool growth of 10 g/d the daily demands for Zn, Cu and Mn for growth (2.4 mg Zn; 0.08 mg Cu; 0.05 mg Mn) and wool production (2.2 mg Zn; 0.07 mg Cu; 0.035 mg Mn) were found to be similar.

Keywords Sheep; fleece-free empty body weight; wool; zinc; copper; manganese; iron

INTRODUCTION

The determination of the mineral requirements for sheep using the factorial model approach (Agricultural Research Council, 1980) requires quantitative data on many aspects of mineral metabolism. At present there is a dearth of information on many of the quantitative aspects of Zn, Cu, Mn and Fe metabolism including the amounts associated with weight gains and wool growth of the grazing sheep.

This paper presents data from a detailed study (Grace, 1983) of the total amounts and the distribution of Zn, Cu, Mn and Fe in the organs and tissues and the amounts of Zn, Cu, Mn and Fe which are associated with gains in weight of the fleece-free empty body and clean fleece of young New Zealand Romney sheep grazing ryegrass/white clover pastures.

EXPERIMENTAL

Animals and Experimental Design

Fifty weaned New Zealand Romney lambs (25 wethers and 25 ewes), mean age 105 days and weighing an average 25.4 kg were randomly divided, within a sex, into 5 groups of 10 (5 wethers and 5 ewes per group). The study began in early December and continued for 300 days. One group was slaughtered immediately whereas the other 4 groups were rotationally grazed on ryegrass/white clover pasture until they were slaughtered.

All sheep were weighed weekly and at about 10-weekly intervals a group was slaughtered and the various tissues and organs removed and subsampled. The pasture was sampled at weekly intervals and bulked on a monthly basis.

Collection of Organs and Tissues

Full details on the slaughtering procedure, collection, weighing and subsampling of the organs and tissues have been published (Grace, 1983). The animals were weighed and shorn before slaughter and the brain, lungs, heart, spleen, liver, kidney, pancreas and the entire digestive tract (from which contents had been removed) dissected out. Muscle, bone, skin, wool and blood were subsampled. The wool was hand scoured and washed in distilled water. The total amounts of bone, muscle and blood were calculated (Grace, 1983) from published equations relating the above parameters to body weight (Hodgetts, 1961; Broad and Davies, 1981).

Analytical

Full analytical details of the sample preparation and the ashing procedures have been described elsewhere (Grace, 1983). The Zn, Cu, Mn and Fe were determined by inductively coupled argon plasma spectrophotometry (Lee, 1983).

Statistics

The relationships between the Zn, Cu, Mn and Fe content of the fleece-free empty body and the fleece-free empty body weight were determined by regression

TABLE 1 The mean quantities (mg) of Zn, Cu, Mn and Fe associated with the organs and tissues of grazing sheep.

Fleece-free empty body weight (kg)	21.6	41.2	21.6	41.2	21.6	41.2	21.6	41.2
Clean fleece weight (kg)	1.05	4.10	1.05	4.10	1.05	4.10	1.05	4.10
	Zn		Cu		Mn		Fe	
Organs	31.1	53.6	44.6[1]	75.9	2.3	3.5	86	179
Offal[2]	2.2	3.4	0.7	1.6	0.1	0.2	344	626
Digestive tract	29.7	51.9	2.2	3.8	3.5	8.6	85	144
Muscle	316.0	697.0	9.5	20.9	1.1	2.5	154	539
Bone	155.0	237.0	0.9	1.5	1.0	1.5	116	177
Skin	42.0	52.1	2.6	4.4	2.0	4.9	68	165
Total in fleece-free empty body	576.0	1095.0	60.5	108.1	10.0	21.2	853	1830
Wool	236.0	967.0	7.7	28.7	3.6	14.3	24	94

[1] Of the 44.6 and 75.9 mg of Cu associated with the organs 42.6 and 73.1 mg respectively was stored in the livers of the sheep weighing 21.6 and 41.2 kg on a fleece-free empty body basis.
[2] Includes blood collected during slaughter and the trimmings.

analysis (Snedecor and Cochran, 1967). The fleece-free empty body weight is the weight of a shorn sheep less the contents of its digestive tract.

RESULTS AND DISCUSSION

Pasture Zn, Cu, Mn and Fe Content

The mean monthly Zn, Cu, Mn and Fe concentrations (± standard error) were 25 ± 0.7, 6.7 ± 0.24, Mn 126 ± 8.4 and 1340 ± 427, respectively.

Body Weight Gain and Wool Growth

The mean body weights of the ewes and wethers were not significantly different. During the study the mean body weight gains were within the accepted target of weight gains being 81 g/d over the entire investigation and 130 g/d during the early summer. The mean weights of clean fleece shorn from sheep of mean body weights of 25.4, 32.2, 40.1, 46.0 and 49.7 kg were 1.05, 1.90, 2.90, 3.56 and 4.10, respectively. Although the rate of growth of wool is influenced by many factors, including the season, the mean growth rate of the clean fleece in this study was 10.2 g/d.

The Amounts and Distribution of Zn, Cu, Mn and Fe in the Fleece-free Empty Body Weight of the Sheep

The amounts and the distribution of Zn, Cu, Mn and Fe between the organs and tissues, including the clean fleece for sheep of 21.6 and 41.2 kg fleece-free empty body weight are shown in Table 1.
As there were no significant differences between ewes and wethers the trace element data were combined.

The distribution was different for each mineral element. For example, a large proportion of the Zn was associated with the muscle, bone and wool while 60 to 70% of the Cu was found in the liver. The Mn was found mainly in the digestive tract and wool and as expected about 50% of the Fe was associated with the red blood cells.

The Amounts of Zn, Cu, Mn and Fe Associated with the Gains in the Fleece-free Empty Body and the Fleece

The amounts of Zn, Cu, Mn and Fe taken up with each kilogram gain in the fleece-free empty body were determined from regression equations relating the total amounts in the fleece-free empty body (Y) to the fleece-free empty body weight (X). The regression equations together with the data relating the changes in the Zn, Cu, Mn and Fe content of the fleece-free body and the clean fleece to the increasing fleece-free empty body weight are illustrated in Fig. 1.

The hepatic Cu was excluded when determining the Cu uptake of the tissues and organs of the growing sheep. The liver is a major storage organ for Cu and the rate of Cu uptake by this organ is variable, being more rapid than for other tissues when Cu intakes are more than adequate. During periods of Cu deficiency the Cu is mobilised from the liver but not the other tissues.

Each kilogram increase in the fleece-free empty body was associated with 24 mg Zn, 0.77 mg Cu, 0.47 mg Mn and 55 mg Fe. The mean concentration in clean wool was 220, 7, 3.5 and 23 mg/kg for Zn, Cu, Mn and Fe, respectively.

Using the above data, the daily amounts of Zn, Cu, Mn and Fe associated with the growth of body tissues and the wool in the young sheep can be calculated. For example, assuming a gain in the fleece-free body weight of 100 g/d and a mean wool growth of 10 g/d the daily uptake by growing tissues would be 2.4 mg Zn, 0.08 mg Cu, 0.05 mg Mn and 5.5 mg Fe, while the respective amounts for daily wool growth would be 2.2 mg Zn, 0.07 mg Cu, 0.04 mg Mn and 0.23 mg Fe.

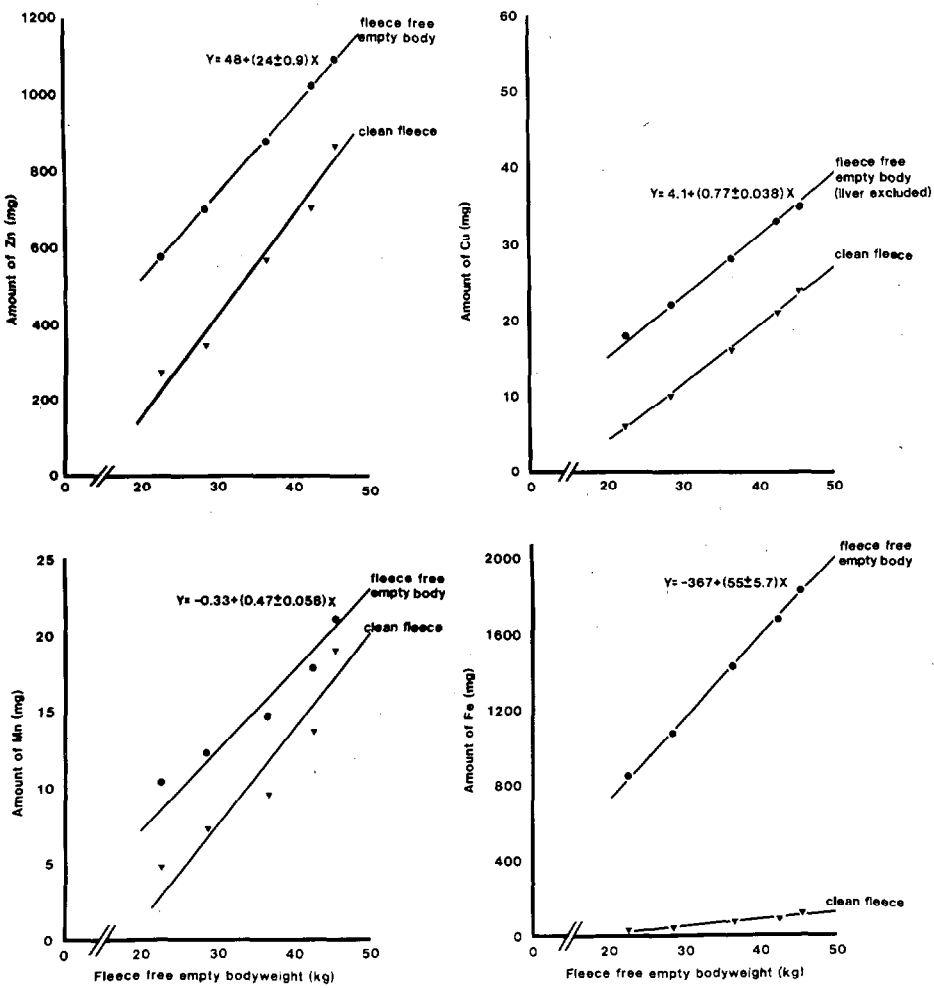

FIG. 1 The changes in the amounts (mg) of Zn, Cu, Mn and Fe in the fleece-free empty body and the clean fleece with the increasing fleece-free empty body weight (kg).

Clearly, when determining mineral requirements of young sheep, the demands of wool growth for Zn, Cu and Mn must be considered as they are similar to those of the fleece-free body-weight gains. This is in contrast to many of the major elements such as Na, K, Ca, Mg and P, where demands of the body tissues are much greater than that of wool (Grace, 1983).

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