An estimation of the dietary allowances of Cu, Zn, Fe, Mn and Se for single- and twin-bearing ewes

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ABSTRACT

Fifty-six pregnant Romney ewes grazing a ryegrass/white clover pasture were divided into 7 groups of 8 and slaughtered at days 62, 81, 100, 115, 125, 135 and 143 of gestation to remove the conceptus (uterine tissue and membranes, placental fluids and the foetus[es]) and determine its total Cu, Zn, Fe, Mn and Se content. The uterus was also removed from 8 ewes just prior to mating. Half the ewes had twin foetuses. The daily rates of deposition of Cu, Zn, Fe, Mn and Se were calculated from the slope of the curves relating the gestational age with the net trace element content of the conceptus. The dietary allowance of Cu, Zn, Fe, Mn and Se for the pregnant ewe was then calculated from the daily deposition rates into the conceptus, determined from this study, and published data on the net requirements for maintenance, coefficients of absorption and DM intakes. The calculated dietary allowances (per kg DM) for single- and twin-bearing ewes, were 7.4 mg Cu, 24 mg Zn, 36 mg Fe, 30 mg Mn and 33 μg Se.

Keywords Sheep; pregnancy; dietary allowance; Cu; Zn; Fe; Mn; Se.

INTRODUCTION

Although trace element deficiencies in New Zealand have been well documented in sheep there is little information on the Cu, Zn, Fe, Mn and Se requirements of the pregnant ewe. With a greater emphasis being placed on the efficiency of sheep production there is a need for more detailed information on the mineral nutrition of the ewe.

This paper presents data on the deposition rate of Cu, Zn, Fe, Mn and Se into the conceptus (uterine tissue and membranes, placental fluids and foetus(es) of single- and twin-bearing ewes. The information was then used to calculate the dietary allowances of Cu, Zn, Fe, Mn and Se for the pregant ewe.

EXPERIMENTAL

Animals and Experimental Design

In early March 100 Romney 5-year old ewes, weighing on average 56 kg and grazing a ryegrass/white clover pasture, were mated to 3 Romney rams fitted with mating harnesses. The date of service of each ewe was noted and the pregnant ewes were sorted in 7 groups of 8 and slaughtered to remove the conceptus at days 62, 81, 100, 115, 125, 135 and 143 of gestation. 8 ewes were also slaughtered to remove the non gravid uterus prior to mating. Ewes were x-rayed at day 95 to determine whether they were carrying singles or twins to ensure that subsequent slaughter groups had equal numbers of single- and twin-bearing ewes.

Pasture samples were collected at about weekly intervals and bulked over monthly periods.

Procedures at Slaughter

A detailed account of the procedures has been given elsewhere (Grace, Watkinson and Martinson, 1986). Briefly, the ewes were fasted overnight, shorn, weighed and killed by cutting their throat. The conceptus was quickly removed and weighed. The placental fluids were sampled and weighed while the foetus(es) was separated from the uterus and membranes so that they could all be weighed separately. The tissues were stored at -10° C. All care was taken to prevent trace element contamination of the tissues and all samples were handled and stored in plastic containers washed with distilled water.

Preparation of Samples and Analytical Methods

The frozen placental fluids were thawed and subsampled while the frozen uterine tissue and foetus were cut into small pieces and finely minced before being subsampled (Grace, Watkinson and Martinson, 1986). All samples of pasture and animal tissues were wet ashed (concentrated HNO_3: 70% $HClO_4$ 4:1) and Cu, Zn, Fe and Mn determined by inductively-coupled argon plasma emission spectrometry (Lee, 1981) while Se was determined by the method of Watkinson (1979).

Statistical Methods

The relationship between the net trace element content of the conceptus (mineral content of the conceptus less mineral content of the non gravid uterus) and the gestational age was given by the equation

$$\ln y = A\text{-}Be^{-Ct}$$

(Robinson *et al.*, 1977; Langlands *et al.*, 1982) where y was the net trace element content of the conceptus (mg), t was time (d) from conception and A, B and C were constants determined by a least-squares fit to the data. The data from the single- and twin-bearing ewes were analysed separately and the daily rates of deposition of Cu, Zn, Fe, Mn and Se into the conceptus were determined from the slope of the curve

relating the net Cu, Zn, Fe, Mn and Se content to gestational age.

RESULTS AND DISCUSSION

Pasture Composition

The mean (± standard error) monthly mineral concentrations (mg/kg DM) were Cu 5.0 ± 0.46, Zn 27 ± 1.1, Fe 212 ± 39.4, Mn 151 ± 16.5, Se 0.033 ± 0.004, Mo 0.2 ± 0.06 with the S being 3.9 ± 0.33 g/kg DM.

Weight of Conceptus

The mean weights for the conceptus and foetus(es) at 81, 125 and 143 days of gestation are given in Table 1. At day 143 of gestation the mean weight (g) (± standard error) of the conceptus of the single-bearing ewe was 8383 ± 218 with the respective weights (g) for the placental fluids, uterine tissues and foetus being 1626 ± 81, 1410 ± 101 and 5347 ± 176. Likewise in the case of the twin-bearing ewe at day 143, the mean weight (g) (± standard error) of the conceptus was 12 793 ± 690 while those of the placental fluids, uterine tissue and both foetuses were 2722 ± 271, 1839 ± 92 and 8232 ± 184 respectively.

The Trace Element Content of the Conceptus

The quantities of Cu, Zn, Fe, Mn and Se associated with the foetus(es) and conceptus at day 81, 125 and 143 of gestation in single- and twin-bearing ewes are shown in Table 1.

At day 81 or about halfway through gestation, when the foetus was still relatively small compared to the other tissues of the conceptus, only about 48% of the total Cu, Zn and Mn, and about 17% of the Fe and Se in the conceptus were associated with the foetus(es). Just prior to parturition, when the foetal weight was 64% of the total conceptus, the amounts of Cu, Zn and Mn in the foetus(es) were about 88% while the amounts of Fe and Se were about 72% of the total Cu, Zn, Mn, Fe and Se present in the conceptus. Further it was observed that the foetal liver was an important storage organ for Cu as it contained 40% of the Cu in the foetus prior to parturition.

The daily rates of uptake of Cu, Zn, Fe, Mn and Se by the conceptus at day 143 are given in Table 2.

The differences between single- and twin-bearing ewes in the rates of uptake of the trace elements by the conceptus just prior to parturition are small. However for most of the gestation period, particularly during the first and second trimester, it was observed that the rates of deposition into the conceptus were greater for the twin-bearing ewe than for the single-bearing ewe (Grace *et at.*, 1986).

Estimation of the Dietary Allowance of the Pregnant Ewe

The daily rates of deposition of the trace elements by the conceptus were then used to estimate the net requirement, the gross requirement and the dietary allowance of Cu, Zn, Fe, Mn and Se for the pregnant ewe, by the factorial approach (Table 2) (Agricultural Research Council, 1980).

The net requirement of the pregnant ewe (Table 2) is the total amount of the trace element which must be absorbed to meet the maintenance needs (that is the endogenous loss), wool growth, as well as the uptake by the conceptus. At present only the Cu and Zn endogenous losses have been measured (Agricultural Research Council, 1980), while the values for Fe, Mn and Se are estimates (Suttle, 1979; Grace and Watkinson, 1985).

The gross requirement (Table 2) includes an

TABLE 1 The mean weights (g) of the foetus(es) and conceptus as well as the quantities (mg) of Cu, Zn, Fe, Mn and Se associated with the foetus(es) and conceptus at day 81, 125 and 143 of gestation in single- and twin-bearing ewes.

Gestation age (days)	81		125		143	
	Foetus(es)	Conceptus	Foetus(es)	Conceptus	Foetus(es)	Conceptus
Single-bearing						
Tissue weight	296	1634	3308	5203	5347	8383
Cu	0.46	1.14	8.0	9.0	14.4	15.7
Zn	9.6	18.5	61	77	110	129
Fe	5.3	29.2	118	179	220	309
Mn	0.47	0.93	3.1	3.4	5.1	5.5
Se	0.008	0.061	0.15	0.25	0.234	0.37
Twin-bearing						
Tissue weight	668	3694	5878	9196	8232	12793
Cu	1.7	2.9	12.3	13.9	21.8	23.7
Zn	17.8	38.7	109	130	152	176
Fe	15.9	77.5	265	353	374	460
Mn	0.74	1.69	3.9	4.3	6.2	6.7
Se	0.021	0.12	0.26	0.40	0.39	0.56

TABLE 2 *Daily deposition rate in the conceptus and calculated net requirement, gross requirement and dietary allowance of Cu, Zn, Fe, Mn and Se for single- and twin-bearing ewes at day 143.*

		Uptake by the conceptus (mg/d)	Net requirement (mg/d)	Gross requirement (mg/d)	Dietary allowance (mg/kg DM)
Cu	Single	0.63	0.83	10.4	7.4
	Twin	0.74	0.94	11.8	7.4
Zn	Single	3.6	9.4	31	24
	Twin	4.2	10.7	33	21
Fe	Single	9.2	10.0	50	36
	Twin	10.1	11.9	59	37
Mn	Single	0.08	0.87	42	30
	Twin	0.12	0.88	44	28
Se	Single	0.01	0.02	0.05	0.033
	Twin	0.01	0.02	0.05	0.031

estimate of the efficiency of absorption and is the amount of Cu, Zn, Fe, Mn and Se ingested, that is necessary to meet the needs of the pregnant ewe. It is greater than the net requirement as only a fraction of the ingested trace element is absorbed. In calculating the gross requirements from the net requirement data the coefficients of absorption used were Cu 0.08, Zn 0.3, Fe 0.2, Mn 0.02 and Se 0.4 (Agricultural Research Council, 1980).

For the grazing animal it is more practical to have the trace element requirements expressed as a dietary allowance, i.e. in terms of their concentration in the pasture. The dietary allowance (Table 2) was determined by dividing the gross requirement by the DM intakes which were taken for a 50 kg sheep to be 1.4 and 1.6 kg DM/day for a single- and twin-bearing ewe respectively (Rattray, 1978).

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