Studies on magnesium in ruminant nutrition

10. Effect of lactation on the excretion of magnesium and faecal dry matter by grazing monozygotic twin cows

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1. The excretion of magnesium in urine, milk and faeces and of faecal dry matter (DM) by grazing monozygotic twin cows has been determined at intervals throughout four grazing seasons.

2. In Expt 1 three sets of twins were used to study the within-pair variance in the excretion of Mg and faecal DM. It was found that the variation within pairs was non-significant and small, less than 5% of the overall mean for all but one of the measurements made. The variation in urinary excretion of Mg within pairs was significant ($P < 0.05$) in 1962.

3. In Expt 2 the effects of lactation on the excretion of Mg and faecal DM were studied. Only one of each of the monozygotic twins was in milk at a time, each twin being in milk for one season.

4. There were no significant differences in faecal nitrogen within and between pairs. On average, lactation increased faecal DM by 30% in 1964 and 24% in 1965.

5. The effect of lactation on urinary Mg was not consistent. For faecal Mg the effect of lactation was a simple reflection of the increased faecal DM since lactation had no effect on the concentration of Mg in the faeces. There was no correlation between the Mg excretion in urine and milk, either singly or together, with faecal Mg excretion.

6. The concentration of Mg in milk differed between twins and increased with length of lactation.

7. Mean intakes of Mg by the cows have been calculated from the values for the intake of DM and the Mg content of cut herbage and compared with total excretion of Mg in urine, milk and faeces. There was a significant correlation ($P < 0.05$) between the sets of values but estimated intakes were lower ($P < 0.05$) than excretions. The differences between intake and excretion differed between periods ($P < 0.001$), being greatest between July and September. Selective grazing was considered to be the main factor responsible for these differences.

Hypomagnesaemic tetany is still a cause of economic loss in intensive systems of grass management for milk production, and more information is required on the metabolism of magnesium by the grazing cow under these conditions. It is not possible to conduct balance trials with grazing cows (Pritchard, Pigden & Folkins, 1964), but much indirect information on their metabolism may be gained by following changes in the excretory pattern of Mg in urine, faeces and milk, when the cows are at pasture. For example, the adequacy of the dietary Mg intake may be assessed by changes in the excretion of Mg in urine (Rook & Balch, 1958).

Lactation increases both voluntary food intake (Hutton, 1963; Campling, 1966) and Mg requirements, the increase in Mg requirements of the cow being determined by its milk production. Whether the increase in food intake is sufficient to meet the Mg requirements for lactation will depend upon a number of factors, including the concentration and availability of Mg in the herbage. Thus it is difficult at any instant to predict whether a milking cow is more susceptible to hypomagnesaemia and to hypo-

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magnesaemic tetany than a comparable non-lactating cow kept under the same conditions.

There are large variations from animal to animal in the metabolism of Mg (Field, McCallum & Butler, 1958) which has necessitated applying all experimental treatments to each animal. In studying the effects of lactation on the Mg metabolism of dairy cows such an experimental design is not possible and a large number of unrelated animals would have to be used, the number depending upon the magnitude of the effect of lactation on each aspect of metabolism studied. However, if the factors controlling the Mg metabolism of the cows are genetically controlled, the same precision will be gained by using much smaller numbers of monozygotic twins, the reduction depending upon the degree of genetic control.

Since observations on the genetic control of Mg metabolism of cows were not available, the seasonal changes in the excretion of Mg by lactating monozygotic twins at pasture were followed through two grazing seasons. The differences within twins in all but one of the factors studied were found to be small; a second experiment was carried out to study the effect of lactation on the Mg metabolism of the grazing cow.

A preliminary report on part of the study has been already published (Field, 1966).

EXPERIMENTAL

Animals. The cows used were four pairs of monozygotic twins (referred to as cows A to H). Of the four pairs, one was Friesian (A and B) and the remainder Friesian × Ayrshire. They were all about 5 years old at the commencement of the experiments and the mean weight of each pair ranged from 400 to 625 kg. No clinical abnormalities were observed in the experimental animals during the two experiments.

Expt 1. The cows were used to study the within-pair uniformity in the excretion of Mg in urine, faeces and milk and of dry matter (DM) in faeces. They were at pasture during the period May to September 1962 and May to August 1963. Cows A and B had calved in November 1961, cows C and D in February 1962 and E and F in May 1962. Cows E and F developed the vice of milk sucking in the field soon after the final collection in 1962 and were replaced by G and H. In 1963 cows A and B calved in February and the remainder in March. Samples of faeces and urine were collected on five successive days for five periods in 1962 and three in 1963.

Expt 2. The cows were used to study the effect of lactation on the excretion of Mg in the urine and faeces and on faecal DM. It was arranged that only one of each pair of identical twins was in milk in each of 2 years, each twin being in milk for only 1 year. Cows B, C and H calved in March 1964 and cows A and D in February 1965. The effect of lactation on each aspect of metabolism was taken as the difference between the lactating and non-lactating twin, provided the sign of the difference was the same in both years. Unfortunately, one pair was discarded in 1965 because cow G failed to become pregnant. There was a total of twelve collection periods in 1964 and eight in 1965.

Diets. The sward grazed by the cows in Expt 1 was an S23 perennial rye grass–wild white clover mixture sown in 1959. The cows were alternated between two paddocks, 2 and 3 acres, and a compound fertilizer containing potash, nitrogen and phosphate (K_2O, 18%; N, 12%; P_2O_5, 11·8%) was given at a rate of 3 cwt/acre in April, May and August 1962 and in March, August and September 1963.

The cows received 2 kg concentrates at each milking, except for A and B, which were low milk yielders. The concentrates given to the cows 7 days before and during a collection period were from the same batch supplied by the mills.

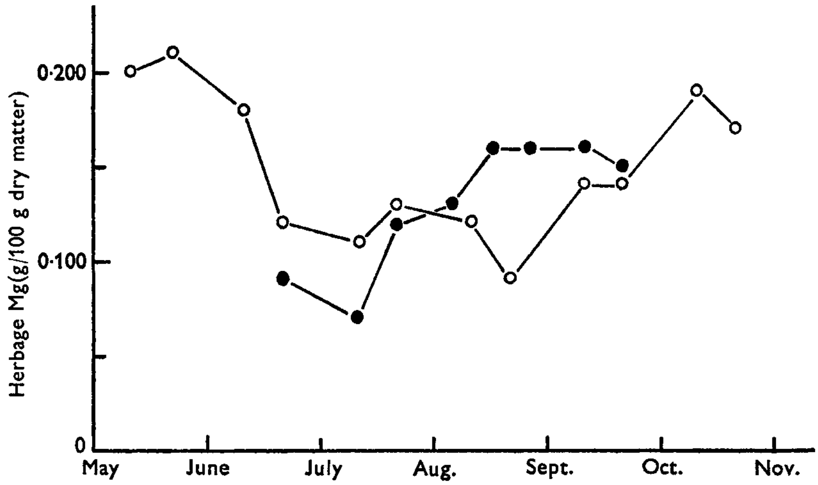

Fig. 1. Change in the concentration (g/100 g dry matter) of magnesium in samples of herbage cut from the sward in 1964 (○) and 1965 (●).

Before Expt 2, one paddock was reseeded in October 1963 with a timothy–meadow fescue mixture. The paddocks were given Nitro-chalk (3 cwt/acre) in March 1964 and 1965. Samples of herbage for chemical analysis were taken on the last day of each collection period during Expt 2. The mean values for the concentration of Mg in the samples of herbage taken in each collection period are shown in Fig. 1.

Estimation of total excretion. Chromium sesquioxide (Cr_2O_3) was used to predict the amount of faecal DM, and creatinine the volume of urine voided (Field, 1964). Each cow was given a capsule containing 20 g Cr_2O_3 paper (Greenhalgh & Runcie, 1962) by balling gun at 08.00 and 17.00 h for 14 days before the first collection period and throughout each grazing season. The mean daily output of creatinine in the urine of each cow was determined before the commencement and at the end of the experimental period in each year. The output ranged from 8·7 to 16·5 g/day.

Samples of urine and faeces were collected by an attendant at each milking. The faeces were taken directly from the rectum, mixed and a representative sample (100 g) was taken for chemical analysis. The samples were pooled for each collection period. A portion (10 ml) was taken from each urine sample and placed in a bottle containing 2 ml 50% (v/v) acetic acid; a few drops of toluene were added and the bottle and contents were stored at 4° until required for chemical analysis. Each milk collection was weighed, mixed with a stainless steel plunger and 2% taken for chemical analysis. The samples of milk were pooled in the same way as those of the faeces and stored in bottles containing formaldehyde as preservative (0·5 ml, 36% (w/v) formaldehyde/100 ml milk).

The methods of analysis for Mg in the samples of urine and faeces, Cr_2O_3 in faeces and paper, and creatinine in the urine were those described previously (Field, 1964). Samples of herbage were treated in the same manner as faeces. Before sampling for chemical analysis, the milk was brought to 37° by standing the sample bottles in a water bath. Total Mg in milk was determined in a trichloroacetic acid filtrate (White & Davis, 1958). The method used for estimating Mg was the same as that used for faeces and urine.

Estimation of herbage dry-matter digestibility. Concentration of N in faeces was used as an index of DM digestibility of herbage. The relationships between these two variables were the same as those used in a previous study (Field, 1967).

Statistical analysis. Variance due to periods, between twins, periods × between-twin interaction, within twins and period × within-twin interaction were isolated for each factor studied and their significance was tested using the period × within-twin interaction as the error term. In 1964 and 1965 the effects of lactation and the period × lactation were also examined. Any values expressed as a percentage were subjected to Arcsin transformation before the analysis of variance.

RESULTS

Expt 1

The mean individual values for the daily excretion of Mg in urine (UMg), milk (MMg), faeces (FMg) and total excretion (TMg) in 1962 and 1963 are given in Table 1. The differences within pairs were not significant for any factor studied except UMg in 1962. The values for UMg in each period were higher for cow B than for A

Table 1. *Mean output of magnesium in urine (U), milk (M) and faeces (F) (g/day) and faecal dry matter (F_{DM}, kg/day) by the individual cows in 1962 and 1963*

(Values for twin pairs AB, CD, EF and GH)

		A	B	C	D	E	F	G	H	SE
1962	U	1·40	2·29	2·07	1·98	3·81	3·61	—	—	0·185
	M	1·15	1·25	2·10	2·11	2·01	1·71	—	—	0·039
	F	17·1	16·2	23·0	22·9	19·2	19·4	—	—	0·477
	T*	19·6	19·7	27·2	27·0	25·0	23·7	—	—	0·508
	$\frac{100\,(U+M)}{T}$†	13·0	18·0	15·3	15·1	23·3	18·2	—	—	
	F_{DM}	4·60	4·69	5·43	5·28	4·03	3·93	—	—	0·047
1963	U	0·89	0·34	0·70	1·79	—	—	1·71	2·54	0·323
	M	1·43	1·39	2·16	2·33	—	—	1·65	1·71	0·115
	F	16·4	15·4	20·6	19·8	—	—	19·4	18·6	0·527
	T*	18·7	17·1	23·5	23·9	—	—	22·8	22·9	0·564
	$\frac{100\,(U+M)}{T}$†	12·4	10·1	12·2	17·2	—	—	14·7	18·6	
	F_{DM}	3·28	3·07	3·96	3·87	—	—	3·71	3·57	0·125

* Total = (U+M+F)
† % apparent availability.

in 1962 but not in 1963. The differences within other pairs in 1962 were not significant. The coefficients of variation within pairs were much larger for UMg than those for FMg and TMg. The values in 1962 and 1963 were respectively 12·8 and 32·4 for UMg, whereas they were less than 3 for FMg and TMg.

The between-twin variance was much greater than the within-twin variance for all factors studied except (U+M)/T. For UMg, FMg and TMg, this difference was due mainly to the feeding of a Mg-rich concentrate to two pairs, for MMg to the large variation in milk yield between the twins and for F_{DM} to the differences in live weight between the twins.

The mean individual concentrations of Mg in milk and faeces are given in Table 2. The differences within pairs for the concentration in milk were significant only in 1963 ($P < 0·001$), but were small relative to the differences between twins. The coefficients of variation within pairs were 1·21 in 1962 and 4·31 in 1963. The differences within pairs in the concentration of Mg in faeces were not significant, the coefficients of variation being less than 0·5 in both years.

Table 2. *Mean concentration of magnesium in milk (M) (mg/100 ml) and in faeces (F) (g/100 g dry matter) excreted by individual cows*

(Values for twin pairs AB, CD, EF and GH)

		A	B	C	D	E	F	G	H	SE
1962	M	12·3	12·6	11·4	11·4	11·4	11·1	—	—	0·152
	F	0·388	0·364	0·445	0·444	0·486	0·505	—	—	0·010
1963	M	11·6	11·3	10·6	10·7	—	—	9·0	7·9	0·148
	F	0·502	0·503	0·521	0·511	—	—	0·522	0·524	0·009
1964	M	—	9·93	9·18	—	—	—	—	6·84	0·366
	F	0·482	0·500	0·528	0·514	—	—	0·506	0·482	0·012
1965	M	10·50	—	—	10·23	—	—	—	—	0·107
	F	0·404	0·398	0·390	0·398	—	—	—	—	0·0085

The fractions of TMg excreted in the urine and milk by the individual cows are given in Table 1. There were no significant differences within pairs in either year with the single exception of pair AB in 1962; the mean values were 13·1% for A and 17·9% for B. In 1962 the values for pair EF were significantly greater ($P < 0·01$) than those for either pair AB or CD. On the other hand, the values for pair AB were significantly smaller ($P < 0·05$) than those for either pair CD or GH in 1963.

The mean individual values for the daily excretion of DM in the faeces are also given in Table 1. The differences within twins were small and non-significant and the coefficients of variation within pairs were less than 1·5% for both years.

Expt 2

Faecal dry-matter excretion. Mean daily values for the faecal DM of the individual cows in 1964 and 1965 are given in Table 3, together with those for the concentration of N in faeces. The effect of lactation on the faecal DM, as measured by the differences within pairs, was highly significant ($P < 0·001$) each year; on average it increased faecal DM by 30% in 1964 and by 24% in 1965. The differences between twins were significant ($P < 0.01$) in 1964 but not in 1965. In 1964 pair AB excreted significantly ($P < 0.05$) more faecal DM than the smallest pair GH. The differences within and between pairs in the concentration of N in faeces were not significant in either year.

The mean daily excretion of faecal DM and mean concentration of N in the faeces voided in each period in 1964 and 1965 are given in Table 4. The values for faecal DM ranged from 3·23 to 4·45 kg/day in 1965. The corresponding ranges for the concentration of N in faeces were 1·66–2·99% and 1·72–2·36%. The differences between periods for both faecal DM and N concentration were highly significant ($P < 0.001$) in both years. There was a significant negative correlation between the two variables in 1964 ($r = -0.712$, df 10, $P < 0.01$) but not in 1965. This failure to reach significance was due to the fewer collections and the smaller ranges of the two variables in 1965, in which the collection periods started at the end of June, thus missing the high May values for faecal N concentration.

Table 3. *Mean excretion of faecal dry matter (F) (kg/day) and mean percentage concentration of nitrogen (g/100 g) in faeces of individual cows in* 1964 *and* 1965

(Values for twin pairs AB, CD and GH)

		A	B	C	D	G	H	SE
1964	F	3·64	4·47*	4·27*	3·28	3·11	4·27*	0·0978
	N	2·33	2·17*	2·28*	2·11	2·30	2·19*	0·0690
1965	F	4·61*	3·51	3·71	4·29*	—	—	0·0744
	N	2·12*	2·00	1·98	2·00*	—	—	0·0622

* Lactating.

Digestibility and intake of herbage dry matter. The mean values for the percentage digestibility and intake of herbage DM by the cows in each period of 1964 and 1965 are given in Table 4. Values over 70% for the digestibility of DM occurred in May and June, whereas they ranged between 59·7 and 66·5% for the rest of the grazing season.

The mean values for the intake of DM in each collection period ranged from 9·8 to 15·5 kg/day in 1964 and from 9·9 to 12·3 kg/day in 1965. There was a positive correlation between digestibility and mean intake of herbage DM by the cows in 1964 ($r = 0.853$, df 10, $P < 0.01$) but not in 1965.

The differences within twins in intake between lactating and non-lactating cows were 22% for AB, 29% for CD, 36% for GH in 1964 and 31% for AB and 15% for CD in 1965. There were significant differences between twins ($P < 0.05$) in intake of herbage per unit live weight or per unit live weight$^{0.73}$; values were higher for pair CD than for AB in 1964 and 1965, and higher for pair GH than for either of the other pairs in 1964. The mean DM intakes (kg/100 kg live weight day) were respectively 2·00 for AB, 2·20 for CD and 2·79 for GH in 1964 and 1·81 for AB and 2·15 for CD in 1965.

Excretion of magnesium. The mean daily values for UMg, MMg and FMg for individual cows in 1964 and 1965 are given in Table 5. In 1964 and 1965, values of UMg for the lactating members of pairs AB and CD were less ($P < 0.05$) than those of their non-lactating twins. For pair GH, however, in 1964 the value of UMg for the

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Table 4. *Mean excretion of faecal dry matter (F) (kg/day), mean percentage concentration of nitrogen in faeces, mean percentage digestibility (D) and mean estimated intake (I) (kg/day) of herbage dry matter eaten by three pairs of cows in* 1964 *and by two pairs in* 1965, *periods* 1–12

	1	2	3	4	5	6	7	8	9	10	11	12	
							1964						
	May	May	June	June	July	July	Aug.	Aug.	Sept.	Sept.	Oct.	Oct.	SE
F	3·23	3·68	3·40	3·41	4·33	4·17	4·45	3·85	3·97	3·81	4·18	3·60	0·0138
N	2·58	2·99	2·68	2·38	2·03	1·86	1·66	1·76	2·34	2·38	1·96	2·13	0·0976
D	74·0	76·2	74·6	72·8	63·3	61·6	59·7	60·7	66·3	66·7	62·6	63·7	—
I	12·4	15·5	13·4	12·6	11·8	10·9	11·0	9·8	11·8	11·4	11·2	9·9	0·363
							1965						
				June	July	July	Aug.	Aug.	Aug.	Sept.	Sept.		
F	—	—	—	3·62	4·89	3·93	4·16	3·83	3·97	3·60	4·25	—	0·105
N	—	—	—	2·05	1·72	2·11	1·93	2·28	2·36	2·04	1·73	—	0·0880
D	—	—	—	70·6	60·3	64·1	62·3	65·7	66·5	63·4	60·4	—	—
I	—	—	—	12·3	12·3	10·9	11·0	11·2	11·9	9·9	10·8	—	0·249

lactating twin H, was greater ($P < 0.05$) than that for G. The differences between pairs in UMg were significant ($P < 0.05$) in 1964 but not in 1965.

The mean values for the concentration of Mg in milk and in faeces are given in Table 2. The differences in concentration between periods were significant in 1964 ($P < 0.01$) and in 1965 ($P < 0.001$); in both years the values increased with duration of lactation.

The effect of lactation on faecal Mg concentration was not significant in either year. The overall means for FMg were 19.0 g/day in 1964 and 15.8 g/day in 1965. The effect of lactation on FMg was highly significant ($P < 0.001$) in both years and was a simple reflection of the increase in faecal DM. The differences between pairs in

Table 5. *Mean excretion of magnesium in urine (U), milk (M) and faeces (F) (g/day) by the individual cows in 1964 and 1965*

(Values for twin pairs AB, CD and GH)

		A	B	C	D	G	H	SE
1964	U	1.52	1.42	1.33	1.84	1.65	2.12	0.144
	M	—	1.13	1.52	—	—	1.40	0.048
	F	17.3	22.0	22.0	16.7	15.6	20.0	0.530
	T*	18.8	24.5	24.8	18.5	17.2	23.5	0.560
	100 (U+M)†/T	8.02	12.1	11.6	10.4	9.7	15.1	
1965	U	0.89	1.78	1.94	0.68	—	—	0.153
	M	1.22	—	—	1.43	—	—	0.045
	F	18.4	13.7	14.3	16.8	—	—	0.466
	T*	20.5	15.5	16.2	18.9	—	—	0.456
	100 (U+M)†/T	10.4	11.5	11.8	11.1	—	—	

* Total = (U+M+F).
† % apparent availability.

FMg were significant ($P < 0.01$) in 1964 but not in 1965. The mean value for pair GH was less ($P < 0.05$) than those for the other two pairs in 1964. The difference within and between twins in TMg was similar to those described for FMg.

The mean values for UMg+MMg, expressed as a percentage of TMg, for the individual cows are given in Table 5. The overall mean was 11.2 in both years. The mean values for the lactating and non-lactating cows in 1964 were 12.95 and 9.35 respectively, the difference being highly significant ($P < 0.001$). The difference between pair AB and CD were not significant in 1964 and 1965, whereas the mean value was higher ($P < 0.05$) for pair GH than for pair AB in 1964.

The mean daily values for UMg, MMg and FMg in each period of 1964 and 1965 are given in Table 6. The differences between periods for UMg were highly significant ($P < 0.001$) in 1964 but not in 1965. The value of 2.73 g/day in early May was greater ($P < 0.05$) than those for the rest of the periods in 1964. For FMg, the differences between the periods were significant in 1964 ($P < 0.001$) and 1965 ($P < 0.01$). In 1964 high values were observed during May and early June and low values in August. The values for FMg were in general smaller in 1965 than in 1964.

Table 6. *Mean output (g/day) of magnesium in urine (U), milk (M), and faeces (F) by the three pairs of cows in* 1964 *and by two pairs of cows in* 1965, *periods* 1–12

	1	2	3	4	5	6	7	8	9	10	11	12	
						1964							
	May	May	June	June	July	July	Aug.	Aug.	Sept.	Sept.	Oct.	Oct.	SE
U	2·73	1·61	1·65	1·49	1·97	1·70	1·81	1·57	1·25	1·14	1·18	1·65	0·203
M	0·94	0·70	0·82	0·69	0·73	0·75	0·60	0·60	0·70	0·65	0·49	0·48	0·068
F	22·6	25·3	21·4	17·9	19·5	17·6	14·1	13·9	19·6	19·9	20·6	15·2	0·749
T*	26·3	27·6	23·9	20·1	22·2	20·0	16·5	16·1	21·5	21·7	22·3	17·3	0·791
100 (U+M)†/T	13·8	8·42	10·3	11·1	13·0	13·3	13·5	13·3	8·97	8·23	7·66	12·14	—
						1965							
				June	July	July	Aug.	Aug.	Aug.	Sept.	Sept.		
U	—	—	—	1·53	1·16	1·68	0·80	1·73	1·43	1·15	1·10	—	0·216
M	—	—	—	0·69	0·58	0·75	0·70	0·70	0·74	0·60	0·53	—	0·089
F	—	—	—	15·3	13·3	15·1	15·1	16·7	16·6	17·9	16·5	—	0·658
T*	—	—	—	17·5	15·0	17·5	16·6	19·1	18·8	19·6	18·1	—	0·644
100 (U+M)†/T	—	—	—	12·4	11·6	13·9	8·98	12·9	11·5	9·12	9·32	—	

* Total = (U+M+F). † % apparent availability.

No significant correlations between UMg and FMg, UMg+MMg and FMg, UMg and TMg, and UMg+MMg and TMg were found in 1964 and 1965. There were, however, significant correlations ($P < 0.01$) between the concentrations of Mg in the samples of cut herbage and the corresponding values of TMg in 1964 ($r = 0.750$) and in 1965 ($r = 0.864$).

The mean values for UMg+MMg, expressed as a percentage of TMg, in each period are given in Table 6. There were no marked seasonal trends in the values, although the differences between periods were significant ($P < 0.05$) in 1964 and 1965. There was a tendency for low values to occur in September.

Table 7. *A comparison of the estimated mean intake (I) (g/day) of magnesium by lactating (L) and dry (nL) cows with the corresponding total output (T) (g/day) in urine, milk and faeces in 1964 and 1965, periods 1–12*

		1	2	3	4	5	6	7	8	9	10	11	12	SE
							1964							
		May	May	June	June	July	July	Aug.	Aug.	Sept.	Sept.	Oct.	Oct.	
L*	I	26·6	35·7	26·9	17·3	14·9	16·4	15·5	10·0	18·4	16·9	24·7	19·1	1·03
	T	29·1	29·3	27·9	23·0	25·9	23·5	20·3	17·9	25·0	23·5	26·2	20·5	
nL*	I	23·1	29·3	21·2	12·7	11·1	11·8	11·0	7·6	14·6	15·0	17·7	14·5	
	T	23·4	25·9	19·8	15·8	18·5	16·7	12·6	14·2	18·2	19·8	18·4	14·0	
							1965							
					June	July	July	Aug.	Aug.	Aug.	Sept.	Sept.		
L†	I	—	—	—	11·8	9·4	14·1	16·0	19·8	20·5	18·0	18·5		0·99
	T	—	—	—	19·7	17·0	18·8	18·9	20·8	19·8	22·1	20·7		
nL†	I	—	—	—	10·3	7·8	12·2	12·7	15·9	17·4	13·5	13·7		
	T	—	—	—	15·3	13·1	16·3	14·2	17·3	17·7	17·3	15·6		

* Three cows.
† Two cows.

Estimated intake of magnesium. The mean values for the estimated intake of Mg by the cows in a collection period were obtained by multiplying the concentration of Mg in the cut sample of herbage by the estimated intake of DM by the cows. The mean values obtained for the lactating and dry cows in 1964 and 1965 are given in Table 7, together with the corresponding values for TMg. In general the mean values for the estimated intake period were lower than the corresponding ones for TMg, and there were significant correlations between the two variables in 1964 ($P < 0.01$) and in 1965 ($P < 0.05$), the values for r being 0·862 and 0·819 respectively. Statistical analysis of the differences between the estimated intake and TMg showed highly significant differences between periods ($P < 0.001$) in both years and the differences were greater for the lactating than for the dry cows in 1964 but not in 1965.

DISCUSSION

Expt 1 showed clearly the great advantage of using monozygotic twins to study changes in the Mg metabolism of cows. Although it was not meaningful to calculate twin efficiency values for each factor studied because of differences between sets of monozygotic twins in live weight, breed and in dietary treatment, the differences within each pair were non-significant and small, less than 5% of the overall mean, for all but one of the factors studied. For UMg, significant differences within pair AB were observed in 1964 and the coefficients of variation were 12·8 in 1962 and 32·4% in 1963. However, in more recent experiments with three pairs of monozygotic twins of the same breed, of similar weights and given the same amount of food, A. C. Field & N. F. Suttle (unpublished) have found a fourfold difference in UMg between sets of twins, an intraclass correlation of 0·927 and a twin efficiency value of 13·7 (i.e. the number of sets of randomly selected animals which a set of identical twins can replace without loss of sensitivity).

No effect of lactation on digestibility of herbage was observed similar to that described by Hutton (1963). It is probable, however, that the indirect method of estimating digestibility from faecal N concentration is unable to detect the small difference (0·7 units) found by Hutton. Since the intake of herbage is the product of faecal DM and a function of digestibility, it follows that, if there is no effect of lactation on digestibility, the effect of lactation on herbage DM intake within a period is measured by the ratio of the faecal DM of the lactating cow to that of its non-lactating twin and is independent of any errors in the estimates of digestibility. Thus the lactating twins ate, on average, 30% more herbage in 1964 and 24% in 1965 than the non-lactating ones. These values are in good agreement with those of Campling (1966) and Elliott, Fokkema & French (1961). On the other hand, Hutton (1963), using monozygotic twin cattle offered freshly cut herbage, found a larger effect of lactation (47%) on voluntary intake. A comparison of the values for the mean intake of DM by the grazing dry cow ($1·93 \pm 0·13$ kg/100 kg live weight) for herbage of a mean digestibility of 64% obtained in the present work and those obtained by other workers using similar animals show good agreement. For example, Hutton (1963) has recorded intakes of 2·05 and 1·56 kg/100 kg live weight for herbage of 70 and 65% respectively and Holmes, Jones & Drake-Brockman (1961) an intake of about 2·0 kg/100 kg live weight for herbage of a higher digestibility. On the other hand, the value for the mean intake of lactating cows ($2·46 \pm 0·205$ kg/100 kg live weight), although the same as that found by Cox, Foot, Hosking, Line & Rowlands (1956), is generally lower than that reported by other workers (Hutton, 1962; Hutton, 1963; Jones, Drake-Brockman & Holmes, 1965). For example, Hutton (1963) has given values lying between 3·16 and 3·70 kg/100 kg live weight depending upon the stage of lactation. There was no relationship between milk production and within-pair differences in DM intake, as described by Hutton (1963). This relation may have been missed by shortage of herbage at times during the period of experiment. It is interesting to note that there was no correlation between within-pair differences in DM intake and the DM intake of the non-lactating twin.

Throughout the experimental period, the values for UMg of the cows were greater than those given by Rook & Balch (1958) for cows whose serum Mg had fallen below the renal threshold. Thus, it can be concluded that the serum Mg was always greater than the renal threshold and that the amount of Mg absorbed from the gut, was sufficient for the Mg requirements of lactation and endogenous loss.

On the question whether a lactating cow is more susceptible to tetany than a dry cow, the results showed that it is impossible to generalize. For two pairs, lactation led to a reduction in the difference between the amount of Mg absorbed from the gut and Mg requirements, as measured by UMg, and consequently to a possible increased susceptibility to tetany in times of low dietary intake of Mg. For the remaining pair, the opposite was the case, probably owing to the high apparent availability (15·1 %) of dietary Mg by the lactating twin (Table 5).

In well-conducted balance trials with both sheep and cows given cut herbage, it has been shown that intake and total excretion of Mg in urine, faeces and milk are approximately equal (see Field, 1967), and the percentage of TMg excreted in urine or in urine plus milk is a measure of apparent availability of herbage Mg. It is not possible to carry out balance trials with grazing animals, but the above equalities may be used to obtain information on intake and availability of herbage Mg, provided their limitations are recognized.

The overall apparent availability of herbage Mg was low in the present experiment. The mean values for availability ranged from 7·7 to 13·9 % during the different periods (Table 6), values within the range found for herbage by Rook & Campling (1962) (2–25 %) and by Kemp, Deijs, Hemkes & van Es (1961) (7–26 %). The values for the apparent availability of herbage Mg for the lactating was higher than that for the non-lactating cows in 1964. The difference (3·5 %) represents, on average, an increased absorption of about 0·84 g/day by the lactating cow.

Theoretically, the difference between the estimated intake of Mg from herbage and TMg is the change in amount of Mg in the body. The mean difference between intake and excretion was −3·2 g/day in both 1964 and 1965. Since this figure represents a cumulative loss of more than 550 g Mg from the body proper and gut contents in 1964, one or both of the sets of values must have been in gross error, especially at certain times in the grazing season. A comparison of the two sets of values with the dietary Mg requirements of lactating and dry cows suggests that the values for TMg are a better estimate of Mg intake. The Agricultural Research Council (1965) give values of 13·8 and 20·1 g/day for the dietary requirements of cows giving 10 and 20 kg milk/day respectively, assuming an overall availability of herbage Mg of 20 %. In the present experiment, the availability of herbage Mg was lower, about 13 % for lactating cows, but the range of milk yields was similar. Using the latter value for availability, the ARC values for dietary Mg requirements of our lactating cows fell from 30 to 20 g/day during the experiments, values in good agreement for those for TMg. For the dry cows, the estimated requirements range from 12 to 19 g/day, which are again in good agreement with values for TMg.

The large differences between the estimated and probable dietary intake of Mg could have arisen from the cows selecting herbage with a higher concentration of Mg than that of the cut herbage and from the values for DM intake being too low. The use of regression equations relating herbage digestibility to faecal N obtained with sheep for lactating and dry cows leads to an overestimation of digestibility (Corbett, 1960) and hence to an overestimation rather than an underestimation of DM intake. The bias resulting from the use of general rather than local equations (Raymond, Minson &

Harris, 1956) cannot be measured, but the good agreement between the present and published values for the DM intake of grazing cows suggests that, although errors in DM intake do exist, it is selective grazing which is mainly responsible for the above differences.

The daily values for intake, as measured by TMg, were similar to those reported by Kemp *et al.* (1961) (10·3–22·4 g/day), higher than those of Rook & Campling (1962) (6·4–19 g/day) and much lower than those of Hutton, Jury & Davies (1965) (18–46 g/day).

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