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MEASURING MILK INTAKE OF LAMBS SUCKLING GRAZING EWES BY A DOUBLE ISOTOPE METHOD

D. E. WRIGHT and J. E. WOLFF

Ruakura Animal Research Station, Hamilton

INTRODUCTION

NUTRITIONAL EXPERIMENTS seeking to understand the relationship between nutrition of grazing ruminants and the growth of their suckling young are hampered by the uncertain accuracy of methods used to measure milk production by the dam or milk intake by the young. Of these methods, weighing the young before and after suckling (Coombe *et al.*, 1960; Brumby *et al.*, 1963) is subject to large errors, while use of oxytocin injections in the dam (McCance, 1959; Lamond *et al.*, 1969) or measuring tritiated water turnover in the young (Macfarlane *et al.*, 1969; Wright *et al.*, 1974) are subject to tenuous assumptions.

Of these techniques, the use of radioactive tracer has two distinct advantages. First, it involves least animal handling and, second, it integrates milk intake over one or two weeks, thereby reducing errors. However, once the young are four weeks old, intake of water from sources other than milk leads to an overestimate of milk intake (Wright *et al.*, 1974).

To overcome this problem, a double tracer method was tested in eight lambs bottle-fed for 12 weeks with weighed amounts of milk containing tritiated water (TOH). During each week the tritium content of the milk was progressively reduced to simulate the dilution of tracer in the ewe's body water. Each week the lambs received an intramuscular injection of a weighed amount of deuterium oxide (D_2O) as the second tracer. Plasma and milk samples were analysed for tracers by liquid scintillation counting or mass spectrometry.

Concurrently a field experiment lasting 12 weeks obtained data from six lactating Romney ewes on pasture with their suckling lambs. The ewes were injected intramuscularly with weighed doses of TOH and the lambs with D_2O at weekly intervals. Ewes and lambs were segregated for six hours to allow equilibration of isotope, after which serial blood samples were taken for analysis of tritium and deuterium. The data were used to calculate body water content and water turnover by standard

procedures (Macfarlane *et al.*, 1974) and milk according to equation (1) (J. R. Luick, pers. comm.).

$$m = \frac{Q(k_L - k_E)}{\alpha_o(e^{-k_E t} - e^{-k_L t})} \quad \text{..... (1)}$$

where m = rate of milk intake (ml/day)

Q = quantity of tritium in lamb at time " t " (cpm)

k_L = fractional decay rate of D_2O in the lamb (day^{-1})

k_E = fractional decay rate of TOH in ewe or artificial milk (day^{-1})

t = time (days)

α_o = concentration of tritium in milk at " t_o ". (cpm/ml milk water)

A derivation of this equation is given by Shipley and Clark (1972).

This paper reports only some of the results from these experiments since only one-tenth of the deuterium analyses have been completed.

Known milk water intake in four 5-week-old bottle-fed lambs is compared in Table 1 with water turnover measured using D_2O alone and with milk water intake calculated from equation (1) using tritium and deuterium analyses. The mean water turnover and calculated milk water intake were, respectively, 5.6% and 4.4% higher than the true water intake.

Water turnover was expected to exceed milk water intake as water is also formed from the oxidation of milk solids. Assuming all lactose and 60% of the protein and fat is oxidized, metabolic water would increase water turnover by some 5 to 6%.

TABLE 1: ACCURACY OF WATER INTAKE ESTIMATES IN BOTTLE-FED LAMBS¹

Lamb No.	Body Water (%)	Water from Known Milk Intake	Water Turnover from D_2O Dilution		Water Intake from D & T Data & Equation (1)	
		(ml/day)	(ml/day)	(% of known)	(ml/day)	(% of known)
602	63.3	1159	1213	104.7	1227	105.9
603	64.9	1077	1126	104.6	1059	98.3
604	65.9	1151	1240	107.7	1285	111.6
606	65.4	1074	1137	105.9	1093	101.7
Mean \pm S.E.				105.7 \pm 0.7		104.4 \pm 2.9

¹ Five-week-old lambs, mean weight 8.4 kg.

Water turnover determined with D_2O is precise but laborious and the consistent results for the four lambs supports the high precision claimed for analysis by mass spectrometry. The use of equation (1) to calculate milk water intake involves measurements of tritium which are less precise than deuterium and the greater variability in the final column of Table 1 may be due either to errors associated with scintillation counting or to incorrect assumptions inherent in this equation.

These assumptions are:

For all lambs:

1. Constant rate of milk intake by lambs during each week.
2. Constant water space during each week.
3. Minimal exchange between hydrogen, deuterium and tritium in body constituents.

For lambs suckling grazing ewes:

4. Cross-suckling does not occur.
5. Specific activity of milk water equals specific activity of plasma water.
6. Equilibration of isotope in body water is complete when blood samples taken.

Obviously these criteria are not always met and errors must be expected although from Table 1 they appear to be small.

A similar conclusion has been reached by J. R. Luick of the Institute of Arctic Biology, Fairbanks, Alaska, who likewise has used TOH and D_2O in hand-reared Holstein calves and estimated milk intakes within $\pm 2.5\%$ of actual intakes.

The results for one grazing ewe and its suckling lamb are given in Table 2. During the 12 weeks the lamb grew an average of 350 g/day and its body water content decreased from 71.1 to 58.7%. The water turnover in the lamb in week 1 was 742 ml/day and increased to 6352 ml/day in week 12. Whereas, in the first week, water turnover was slightly less than the calculated milk water intake, by week 5 only 61% of water came from milk. This proportion decreased by week 9 to 28% and to 11% by week 12. The equivalent intakes of ewes milk were 956, 913, 1211 and 806 ml/day, respectively.

The data may not be typical for the other ewes and lambs in this trial but it can be seen that, by week 5, water turnover was already much higher than milk water intake. Progressively milk water became a smaller proportion of total water flow although total milk intake was still considerable in week 12.

TABLE 2: WATER TURNOVER AND MILK INTAKE IN A GRAZING, SUCKLING LAMB

Age of Lamb (wk)	Lamb Liveweight (kg)	Body Water ¹ (%)	Water Turnover ¹ (ml/day)	Calculated ² Intake of: Water in Milk (ml/day)	Milk ³ (ml/day)
1	5.6	71.1	742	860	956
5	12.6	66.1	1349	822	913
9	22.1	63.7	3892	1090	1211
12	32.1	58.7	6332	725	806

¹ Measured using D₂O² Calculated from equation (1)³ Milk water $\times (1/0.9)$

In conclusion this double isotope technique appears to represent a considerable advance upon previous methods. The assumptions are plausible and are supported by the limited number of results in the validation experiment in Table 1. With this method it will be possible to estimate not only individual milk intakes but also changes in relative body composition, water turnover and, in some circumstances, pasture intake.

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