Effect of diet and physiological state on recycling of urea in Merino ewes

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The recycling of urea to the rumen was studied in Merino ewes during different physiological states using radioactive tracers. The results showed that although the proportion of urea recycled differed, similar amounts were recycled in dry and pregnant sheep over a wide range of N intake. Urea recycling increased significantly during lactation on all diets when compared with non-lactating sheep. Thus, factors other than simple diffusion of urea control urea recycling in sheep although the control mechanisms remain undefined.

Die hersirkulasie van ureum na die grootpens is ondersoek by Merino ooie tydens verskillende fisiologiese toestande deur gebruik te maak van radio-aktiewe merkers. Die resultate toon dat hoewel die verhouding ureum wat gehersirkuleer is, verskil, is dieselfde hoeveelhede gehersirkuleer in droë en dragtige skape oor 'n wye reeks van N inname. Hersirkulasie van ureum het betekenisvol toegeneem tydens laktasie op alle diëte, in vergelyking met nie-lakterende skape. Daar is dus ander faktore as eenvoudige diffusie van ureum wat die hersirkulasie van ureum in skape beheer, alhoewel die beheermeganismes ongedefinieer bly.

Keywords: Urea entry, urea recycling, pregnancy, lactation, ewes, nitrogen intake

Introduction

Ruminants conserve nitrogen by recycling urea into the gut where it is used to enhance microbial protein synthesis. While the extent of recycling can be substantial, especially at low N intakes, it is not certain that recycling plays a role in conservation of N on normal diets, and during different physiological states.

Although Allen & Miller (1976) found that recycling of urea increased, thus allowing more efficient use of dietary N in rapidly growing lambs, there are no studies which have compared the recycling of N as urea in other physiological states where N conservation may be important. Accordingly this report describes the rate of urea entry and the proportion of urea entry recycled in dry (non-pregnant), pregnant and lactating Merino ewes eating diets designed to be representative of those likely to be encountered while grazing.

Materials and Methods

Merino ewes, 5 years old, were housed indoors and fed either chaffed oaten hay *(Avena sativa,* OH); chaffed lucerne *(Medicago sativa,* L); or a 50:50 (w/w) mixture of OH and L at least eight weeks prior to the start of the experiment.

The diets contained 7,9 MJ ME, 11 g N/kg DM; 8,6 MJ ME, 33 g N/kg DM; 8,2 MJ ME, 21 g N/kg DM, respectively, and the ewes eating each diet weighed 38 ± 1, 50 ± 1,4, 54 ± 1,4 kg, respectively, after subtracting fleece weight, and during pregnancy, the weight of the gravid uterus. The ME and N intakes of the ewes are shown in Table 1.

Table 1 Nitrogen and ME intakes of dry, pregnant and lactating Merino ewes fed chaffed oaten hay (OH), chaffed lucerne hay (L) and a 50:50 mixture of these two diets (50:50)

	Physiological state[a]				
Diet	Dry	EP	LP	EL	LL
	Nitrogen intake (g N/day)				
OH	4,21	5,69	7,63	11,45	9,44
50:50	21,14	–	15,75	34,10	29,21
L	21,36	35,83	42,51	51,42	57,59
	ME intake (MJ/day)				
OH	3,01	4,01	4,54	7,47	6,07
50:50	7,53	–	5,79	13,31	11,41
L	5,56	9,82	10,75	13,38	14,00

[a]Dry = non-pregnant; EP = 94 days after mating; LP = 125 days after mating; EL = 20 days after lambing; LL = 50 days after lambing

Measurements of the rate of urea entry, bicarbonate entry and recycling of urea were made on dry ewes, ewes at 94 and 125 days of pregnancy and during lactation at 20 and 50 days after lambing. Each ewe was fed continuously throughout the day (via an automatic feeder) for at least 10 days before measurements were made. Blood samples were obtained through catheters placed in the jugular vein and femoral artery.

[^{14}C]-urea was infused continuously into the jugular vein of each animal for 12 h, and arterial blood samples were taken hourly for the last 4 h. The specific radioactivity of [^{14}C]-urea was determined on these samples by the method of Coccimano & Leng (1967), and of $^{14}CO_2$ by the method of Leng & Leonard (1965). On a subsequent day the procedure was repeated using $NaH^{14}CO_3$ to determine the whole body entry rate of $^{14}CO_2$.

Urea entry rate was calculated as

$$\frac{\text{infusion rate (Bq/min)}}{\text{SRA arterial urea (Bq/mgC)}}$$

$^{14}CO_2$ entry rate was calculated as

$$\frac{\text{infusion rate (Bq/min)}}{\text{SRA arterial } CO_2 \text{ (Bq/mgC)}}$$

Urea recycling rate was calculated as

$$\frac{\text{SRA } CO_2 - C}{\text{SRA Urea} - C} \times {}^{14}CO_2 \text{ entry rate.}$$

This calculation assumes that $^{14}CO_2$ in the gut has equilibrated with plasma $H^{14}CO_3$. Failure to achieve this may result in the underestimation of the urea recycled by perhaps 10% (J.V. Nolan, pers. comm.).

Results

The entry rate of urea (g/day) on each of the dietary treatments and at the five different physiological states is shown in Table 2. Differences between dietary groups largely reflected differences in N intakes. Urea entry rate was significantly related to N intake, the latter accounting for most of the differences between dietary groups.

Urea entry (g/day) = 7,43 (±4,02) + 1,66 (± 0,13) g N intake/day (r^2 = 0,74, $P<0,001$).

Urea entry rate was significantly related to arterial blood urea concentration.

Urea entry (g/day) = 2,03 (± 0,15) arterial urea (mg/l) − 7,33 (± 4,79).

During lactation the concentration of urea in arterial blood and the urea entry rate were lower than values predicted by N intake using the relationships based on non-lactating sheep.

Table 2 The entry rate of urea (g/day) in dry, pregnant and lactating ewes, eating the diets described in Table 1

	Physiological state					
Diet	Dry	EP	LP	EL	LL	± SE
OH	15,6 (2)	13,6 (4)	19,7 (4)	14,5 (4)	23,5 (4)	4,0
50:50	48,1 (6)	–	35,4 (3)	50,0 (6)	45,3 (6)	5,4
L	59,0 (3)	78,4 (5)	89,8 (5)	106,6 (5)	84,5 (4)	5,4
± SE	6,4	7,9	7,1	6,6	6,7	

(n) = number of animals

Significance of effect of diet = $P<0,001$; physiological state = $P<0,001$; diet × physiological state = N.S.

The proportion of urea entry recycled differed with each diet, and with physiological state, as shown in Table 3. As dietary N intake increased the proportion of urea recycled decreased. Urea recycling increased significantly during lactation on all diets when compared with non-lactating sheep.

Discussion

While the proportion of urea recycled differed, similar amounts of urea were recycled in dry and pregnant sheep

Table 3 Percentage of urea entry rate recycled in dry, pregnant and lactating Merino ewes eating the diets shown in Table 1

	Physiological state					
Diet	Dry	EP	LP	EL	LL	± SE
OH	29,7	37,4	23,4	59,4	36,5	3,4
50:50	12,6	–	11,7	34,8	28,3	4,5
L	8,8	4,9	6,2	21,4	19,0	4,4
± SE	4,1	4,9	4,6	4,1	4,2	

Significance of effect of diet = $P<0,01$;

Physiological state = $P<0,001$; diet × physiological state = N.S

over a wide range of N intake. Dramatic changes in urea metabolism observed during lactation, however, included increased recycling, reduced entry rate and lower blood concentration per unit of N intake. Collectively they indicate that the ewe attempts to decrease the wastage of dietary N during lactation at a time when there is an increased demand for N as amino acids for milk synthesis and for protein deposition in gut tissues. This effect is similar to that observed by Allen and Miller (1976) who found that recycling of urea N was greater in rapidly growing lambs than in mature wethers eating similar diets. The results of this study indicate that factors other than simple diffusion of urea control the recycling of urea in sheep, but the mechanisms by which this control is effected remain undefined.

References

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