PREDICTION OF PARAMETERS OF UREA METABOLISM IN SHEEP FROM THE CONCENTRATION OF UREA IN PLASMA

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Summary

Relationships between plasma urea concentrations and the nitrogen intake, entry rate, excretion rate and pool size of urea were derived from studies on 80 sheep (128 experiments) under a variety of nutritional and environmental conditions. In animals in a maintenance state on a given ration, these parameters may be predicted from plasma urea concentration. The use of these relationships is discussed.

I. INTRODUCTION

Weston and Hogan (1968) reported. that in sheep, concentrations of blood urea and ammonia in ruminal fluid are indices of the quality of the feed, but concentrations of substrates in blood or ruminal fluid are difficult to interpret in quantitative terms without measurements of rates of synthesis.

Urea metabolism and the movement of urea through the body fluids of sheep have been examined by using (^{14}C) labelled urea (Cocimano & Leng 1967; Nolan & Leng 1968; Nolan & Leng 1970). The difference between the rate of entry (synonymous here with rates of synthesis of urea) and excretion of urea has been taken as an indicator of the quantity of urea being degraded (Cocimano & Leng 1967). Since urease exists only in the digestive tract, the rate of degradation represents the rate of movement of urea into the areas of bacterial growth, and so is an indicator of the potential for utilisation of urea nitrogen for bacterial cell synthesis.

In the present studies, data on the metabolism of urea in sheep obtained in a wide variety of nutritional and environmental conditions have been examined by regression analysis to evaluate the use of plasma urea concentrations for predicting parameters of urea metabolism.

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II. MATERIALS AND METHODS

(a) Experimental Procedures

The rations and experimental techniques have been described previously (Cocimano & Leng 1967; Cocimano *et al.* 1970; Nolan and Leng 1968; Nolan and Leng 1970).

Mature Merino ewes and wethers (65 animals) and Corriedale ewes (15 animals) were used in a total of 128 experiments. Merinos (113 experiments) ranged in body weight from 25 to 40 kg and Corriedales (15 experiments) from 45 to 69 kg. In 109 experiments, the animals were held in pens indoors and the same parameters. of urea metabolism were also examined in 19 grazing sheep.

Animals were given their experimental diet for at least 12 weeks prior to all studies and were maintaining weight. With penned animals, the daily ration was given in equal portions at regular intervals. Diets used included (a) wholly roughage diets, and (b) mixtures of roughage and concentrate. The daily intake of nitrogen of the penned sheep ranged from 2.8 to 35 g/day. The nitrogen intake of the 19 grazing animals was not accurately assessed.

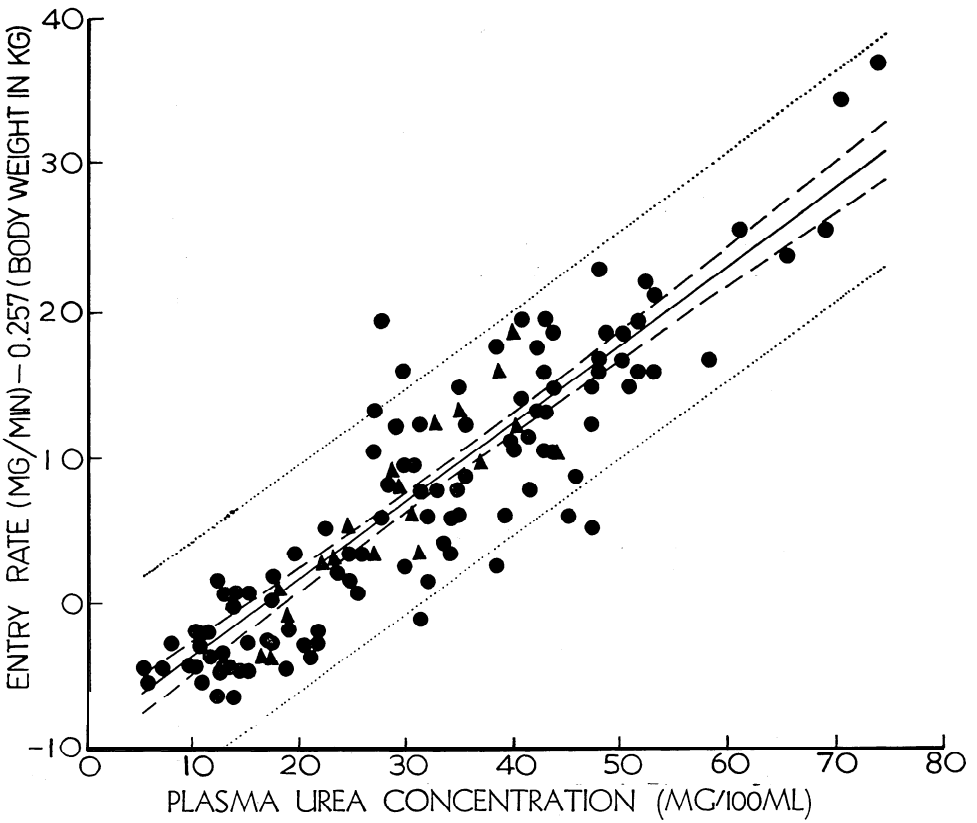

Fig. 1. — Relationship between urea entry rate and plasma urea concentration of sheep. The broken lines represent the 95% confidence limits for the line, the dotted lines the 95% confidence limits for a single observation. (●) penned animals (▲) grazing animals.

TABLE 1

Summary of regression analysis of the parameters of urea metabolism in sheep

	Parameter	Regression Equations			RSD	R^2
(a)	Urea entry rate	Uo	$= -1.13 + 0.588$ (Pc) (SE = 0.0257)		4.66	0.81
		Uo/W	$= 0.0336 + 0.0154$ (Pc) (SE = 0.0007)		0.120	0.81
		*Uo	$= -9.291 + 0.539$ (Pc) (SE = 0.0225)	$+ 0.257$ (W) (SE = 0.0349)	3.91	0.86
		*Uo	$= 1.418 + 1.105$ (Nl) (SE = 0.0506)		4.82	0 83
(b)	Urea excretion rate	Ux	$= -3.69 + 0.426$ (Pc) (SE = 0.0202)		3.46	0.82
		Ux	$= -5.77 + 0.580$ (Pc) (SE = 0.0729)	$- 0.00214$ $(PC)^2$ (SE = 0.000978)	3.39	0.83
		Ux/W	$= -0.109 + 0.0176$ (Pc) (SE = 0 00052)		0.089	0.83
		*UX	$= -9.76 + 0.391$ (Pc) (SE = 0.0181)	$+ 0.1984$ (W) (SE = 0.0320)	2.95	0.87
(c)	Urea pool size	S	$= -0.0923 + 0.231$ (Pc) (SE = 0.0203)		2.50	0.64
		*S/W	$= 0.0177 + 0.00517$ (Pc) (SE = 0.000357)		0.044	0.74
		S	$= -5.342 + 0.176$ (Pc) (SE = 0.0153)	$+ 0.183$ (W) (SE = 0.0204)	1.73	0.69
(d)	Nitrogen intake	*Nl	$= -7.648 + 1.643$ (Pc) (SE = 0.0883)		8.40	0.79

The following symbols are used: urea entry rate (Uo; mg/min), urea excretion rate (Ux; mg/min), urea pool size (S; g), nitrogen intake (NI; g/day), plasma urea concentration (Pc; mg/100 ml), bodyweight (W; kg).

All regression coefficients given are significant at the 0.1% level.

* Indicates equations regarded as being most accurate and most useful for prediction purposes.

(b) Statistical Analysis

Regression analyses were done using an IBM 1620 computer and a programme (Burr 1968). It was possible to obtain a satisfactory fit to the data using models involving linear and quadratic terms.

Multiple regression equations were of the form

$$Y = B_o + B_1 (Pc) + B_2 (W)$$

where B_1, B_2 are the regression coefficients, (Pc) is the plasma urea concentration, and (W) the bodyweight of the sheep. There was a linear relationship between $Y - B_2$ (W) and (Pc) where Y was urea entry rate, urea excretion rate or pool size Figures 1 and 2). Powers of bodyweight ($W^{0.5}$ to $W^{0.7}$) instead of $W^{1.0}$ did not significantly reduce the residual variance in regressions where bodyweight was an independent variable.

III. RESULTS

The relationships between urea entry rate, urea excretion rate and urea pool size, and plasma urea concentration and bodyweight are given in Table 1, and also the relationships between urea entry rate and plasma urea concentration and nitrogen intake. Relationships considered to be most accurate for prediction purposes are marked with an asterisk in Table 1 and are shown in Figures 1 to 5.

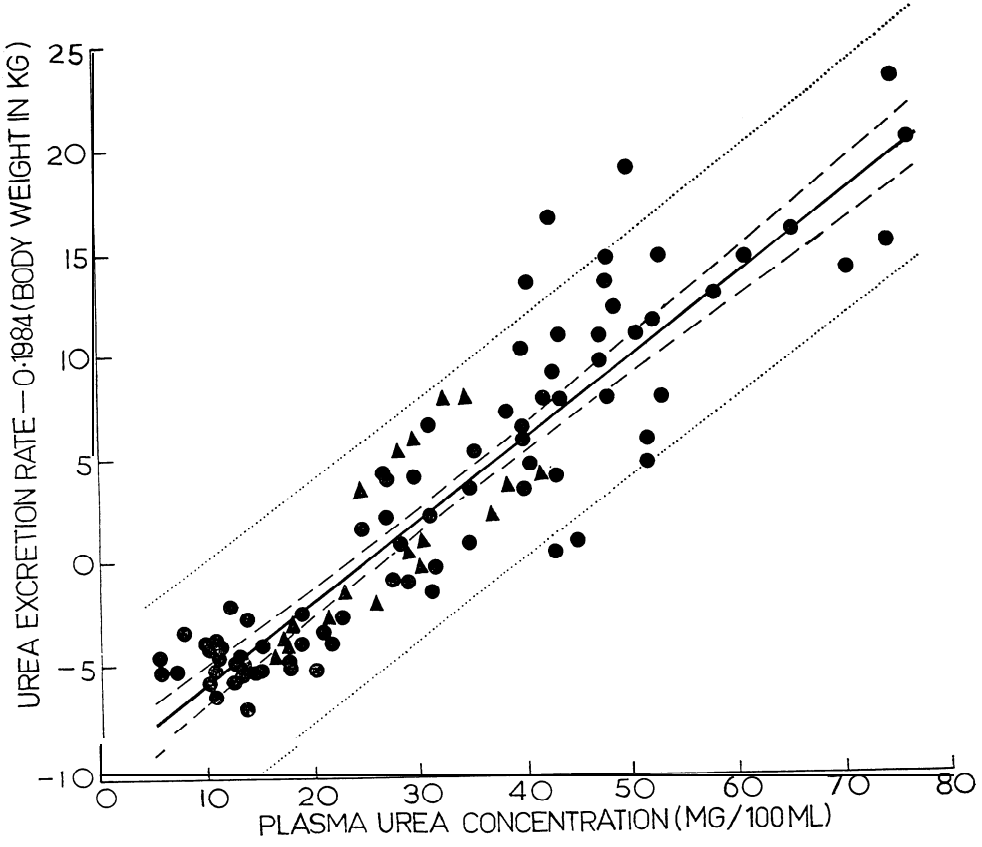

Fig. 2. — Relationship between urea excretion rate and plasma urea concentration of sheep. The legend is given in Figure 1.

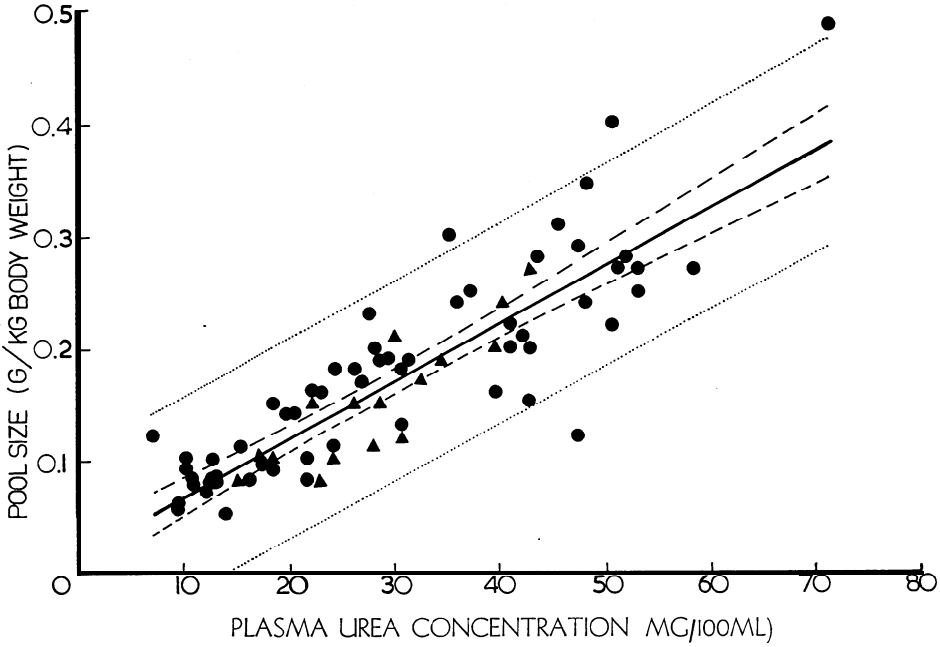

Fig. 3. — Relationship between urea pool size (g/kg) and plasma urea concentration of sheep. The legend is given in Figure 1.

IV. DISCUSSION

The equations presented allow the prediction of nitrogen intake, urea entry rate, urea excretion and pool size from plasma urea concentration, and the accuracy of prediction is increased if bodyweight is also considered.

Although the 95 per cent confidence limits for the predicted mean of each parameter may seem considerable, this estimate obtained by an actual isotope dilution experiment is also subject to considerable biological and technical error (Nolan & Leng 1970). Errors associated with an actual experiment are pooled in the regression analyses and the predicted mean values obtained from the relationships presented here would be expected to give a closer approximation to the true result than a direct determination, provided that the animals studied are within the range of environmental conditions of the animals used to obtain the prediction equations. Also, the urea excretion rate, even in animals examined under controlled conditions, varies considerably in individual animals. The rates of excretion measured over a short period may not be as accurate as the mean values predicted from the relationships presented here, which include day to day and between animal variation.

There are no really satisfactory methods available for measuring nitrogen intake of sheep. It is suggested that the prediction of nitrogen intake from plasma urea concentration may be more accurate and more easily obtained experimentally than one depending on techniques for actually estimating intake of grazing animals (Corbett 1969). A representative blood sample for urea assay

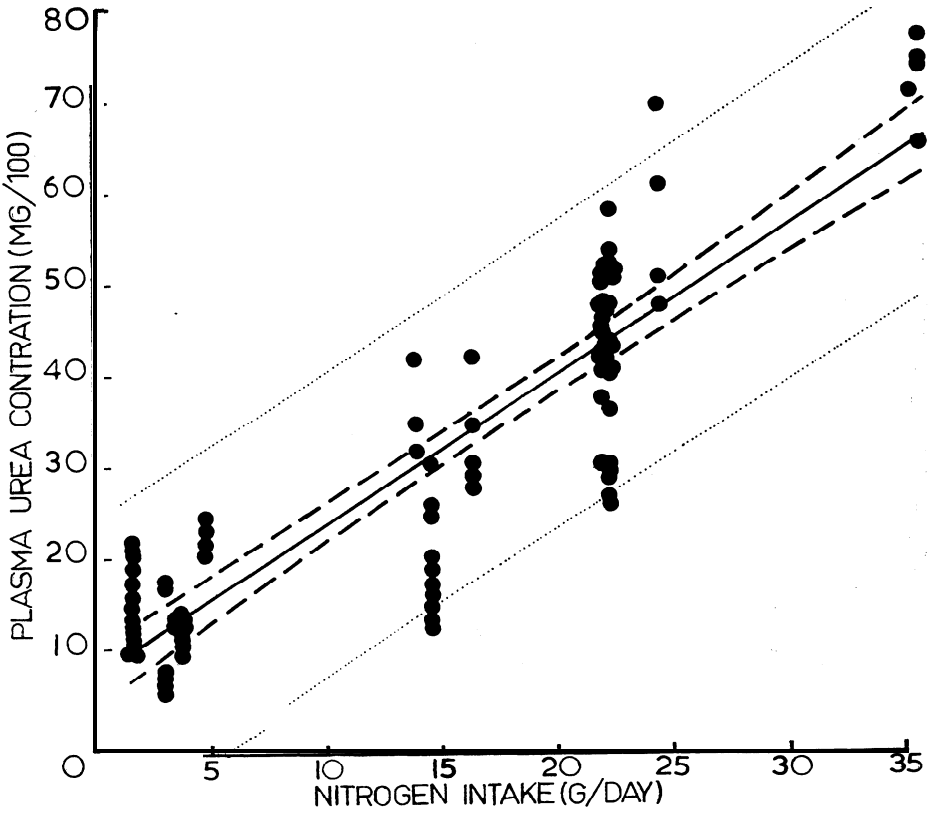

Fig. 4. — Relationship between plasma urea concentration and nitrogen intake of sheep. The legend is given in Figure 1.

can be obtained with the apparatus described by Farrell, Corbett and Leng (1970) which enables a sample to be taken automatically and continuously while an animal is grazing.

It must be stressed that the relationships given here were obtained from experiments. using animals which had been consuming the given rations for at least 12 weeks prior to any experiment. In this time, bodyweight had adjusted to the level of feed intake. Relationships which include bodyweight as an independent variable may not be valid for animals which, have been recently changed from one ration to another, or for animals increasing or losing weight.

The application of these equations together with other measurements, such as those for estimating VFA production in the rumen (for review see Leng 1970) should. aid considerably in the interpretation of nutritional data in grazing trials with sheep.

If the relationships hold under conditions where animals are supplemented with non-protein nitrogen, it should now be possible to examine the response of groups of sheep supplemented in particular grazing situations by using simultaneous estimates of energy and nitrogen intake predicted from ruminal VFA concentration and plasma urea concentration respectively.

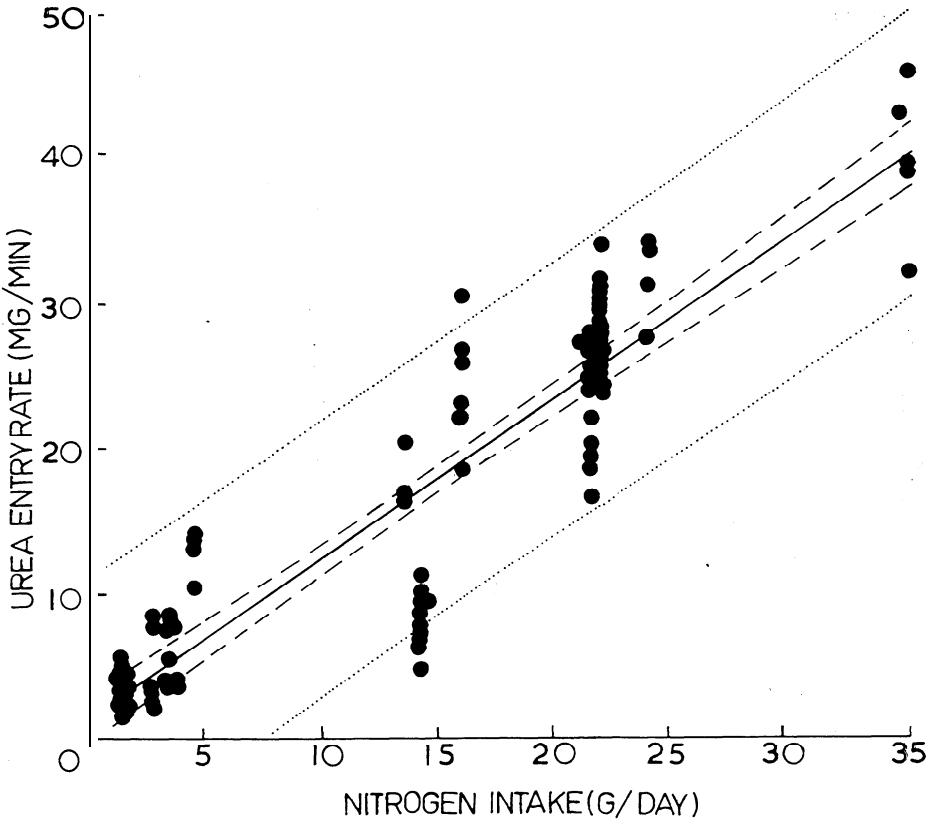

Fig. 5. — Relationship between urea entry rate and nitrogen intake of sheep. The legend is given in Figure 1.

V . ACKNOWLEDGMENTS

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