The Small Ruminant Nutrition System: development and evaluation of a goat submodel

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ABSTRACT: The Small Ruminant Nutrition System (SRNS) is a computer model based on the structure of the Cornell Net Carbohydrate and Protein System for Sheep. A version of the SRNS for goats is under development and evaluation. In the SRNS for goats, energy and protein requirements are predicted based on the equations developed for the SRNS for sheep, modified to account for specific requirements of goats. Feed biological values are predicted based on carbohydrate and protein fractions and their ruminal degradation rates, on forage, concentrate and liquid passage rates, on microbial growth, and on physically effective fiber. The evaluation of the SRNS for goats based on literature data showed that the SRNS accurately predicted the ADG of kids (RMSEP = 32.5 g/d; r^2 = 0.85; CCC = 0.91), and the daily MEI (RMSEP = 0.24 Mcal/d g/d; r^2 = 0.99; CCC = 0.99) and the energy balance (RMSEP = 0.20 Mcal/d g/d; r^2 = 0.87; CCC = 0.90) of goats.

Key words: Goats, Kids, Prediction model.

INTRODUCTION – A computer model to predict site-specific nutrient requirements and feed biological values for sheep was developed, based on the structure of the Cornell Net Carbohydrate and Protein System for Sheep (CNCPS-S; Cannas et al., 2004, 2006). This model, called Small Ruminant Nutrition System (SRNS), uses animal and environmental factors to predict energy, protein, calcium and phosphorus requirements. Feed biological values are predicted based on carbohydrate and protein fractions and their ruminal degradation rates, forage, concentrate and liquid passage rates, microbial growth, and physically effective fibre. A version of the SRNS for goats is under development. Its energy submodel is here presented and evaluated.

MATERIAL AND METHODS – In the SRNS the energy requirement for basal metabolism, expressed as ME for maintenance (ME_m), is adjusted for age, physiological state, environmental effects, physical activity, urea excretion, acclimatization and cold stress, in order to estimate total NE for maintenance (NE_m) and ME_m as shown in Equation 1.

$$ME_m = ((SBW^{0.75} \times a1 \times a2 \times \exp(-0.03 \times AGE)) + ACT + NE_{mcs} + UREA) / k_m \qquad [1]$$

where ME_m is in Mcal/d; and $SBW^{0.75}$ is metabolic shrunk body weight, kg. The factor a1 is the thermal neutral maintenance requirement per kg of metabolic weight for fasting metabolism and movement in confinement; it is assumed to be 0.0777 and 0.0652 Mcal of $NE_m/kg^{0.75}$ for dairy goats and for other breeds, respectively. The factors a2, AGE, ACT, NE_{mcs} and UREA are adjustments described by Cannas *et al.* (2004). The efficiency coefficient k_m is fixed at 0.644.

The CNCPS-S computes average daily gain (ADG) with equations based on the CSIRO (1990) (Eq. 2 to 5), with the modifications proposed by Freer *et al*. (1997). The NE_m is computed using ME_m times k_m as described by Cannas *et al*. (2004). The standard reference weight (SRW) is based on the recommendation of CSIRO (1990).

$$ADG = \frac{RE}{EVG \times 0.92} \qquad [2]$$

$$EVG = (6.7 + 2 \times (L - 1) + \frac{Z_1 - 2 \times (L - 1)}{1 + e^{-6 \times (P - 0.4)}}) \times 0.239 \qquad [3]$$

$$L = \frac{MEI}{ME_m} - 1 \qquad [4]$$

$$P = \frac{FBW}{SRW} \qquad [5]$$

where EVG is the energy content of empty body gain, Mcal/kg of empty body gain; L is the level of feeding relative to maintenance ME minus one unit, Mcal/Mcal; MEI is ME intake, Mcal/d; Z_1 is equal to 16.5; P is a maturity index; FBW is full body weight, kg; SRW is the FBW that would be achieved by a specific animal of a certain breed, age, sex and rate of gain when skeletal development is complete and the empty body contains 250 g of fat/kg (corresponding to BCS 2.8 to 3.0 in ewes using a 0 to 5 scale); ADG is FBW changes, kg/d; RE is retained energy, i.e. NE available for gain, Mcal/d. The SRNS estimates MEI, and the ME requirements for milk production (ME_l) and pregnancy as described by Cannas et al. (2004). The energy available for growth or for body reserves changes depends on the energy balance (EB) after maintenance, lactation, and pregnancy requirements are satisfied.
The predictions of the SRNS on MEI and EB (EB = ($MEI-ME_m-ME_l$) × k_g; where k_g = 0.6) in goats were evaluated using 5 published studies in which balance experiments and indirect calorimetric measurements on lactating does (Aguilera et al., 1990. Brit. J. Nutr. 63, 165; Rapetti et al., 1997. Zoot. Nutr. Anim. 23, 317; Rapetti et al., 2002. Ital. J. Anim. Sci. 1, 43; Rapetti et al., 2005. Ital. J. Anim. Sci. 4, 71) and wethers (Ngwa et al., 2007. Small Rum . Res., in press.) were performed. The predictions of the SRNS on the ADG of kids were evaluated using 8 published studies (Prieto et al., 2000. J. Anim. Sci., 78, 2275; Bueno et al., 2002. Small Rumin. Res. 46, 179; Hadjipanayiotou, 2002. Anim. Feed Sci. Techn., 96, 103; Wuliji et al., 2003. *Small Rumin. Res., 50, 83; Haddad, 2005. Small Rumin.* Res. 57, 43; Amaral et al., 2005. Small Rumin. *Res., 58, 47; Teixeira et al., 20*06. Small Rumin. Res., 63, 20; Fernandes et al., 2007. *J. Anim. Sci., 85, 1014)* in which the *ADG of kids resulting from 31 different feeding treatments on dairy, meat and indigenous breeds was measured. The SRNS predictions were compared with those of the model of Luo et al. (2004), by using the same dataset and the MEI predicted by the SRNS.*
The assessment of the adequacy of the models was carried out with the Model Evaluation System, which is based on statistical techniques discussed by Tedeschi (2006).

RESULTS AND CONCLUSIONS – The publications used to evaluate the SRNS reported only part of the information on feed composition required by the model; therefore, many values were estimated.
Despite this, the SRNS was able to predict accurately and precisely the daily MEI of goats (root of the mean squared error of prediction, RMSEP, = 0.24 Mcal/d; r^2 = 0.99; concordance correlation coefficient, CCC, = 0.99; Figure 1). Milk NE was also predicted with high accuracy (RMSEP = 0.012 Mcal/d; r^2 = 0.99; CCC = 0.99). The EB of lactating goats and wethers was predicted with good accuracy (RMSEP = 0.20 Mcal/d; r^2 = 0.87; CCC = 0.90), with a systematic tendency of slightly underpredicting the EB as the observed values increased (Figure 1).
The SRNS accurately predicted the ADG of kids (RMSEP = 32.5 g/d; r^2 = 0.85; CCC = 0.91; Figure 2). When the ADG predictions were based on the SRNS estimates of MEI and on the ME requirements for maintenance and gain of Luo et al. (2004), the RMSEP increased to 34.9 g/d, mainly due to a fairly large systematic bias (19.2% of the MSEP), which made the regression line significantly different ($P < 0.03$) from the equivalence line (Y = X) (Figure 2). In particular, this model overpredicted the ADG at high observed ADG, and underpredicted the ADG at low observed values. This can be explained by the fact that this model uses a fixed value for the cost of gain, regardless the BW or the relative size of the kids.
In conclusion, the SRNS for goats was able to predict accurately and precisely the MEI and the EB of lactating and non-lactating adult goats and the ADG of kids of dairy, meat and indigenous breeds. This model (http://nutritionmodels.tamu.edu/srns.htm) is free for academic use.

Figure 1. Comparison of observed and predicted daily MEI (left) and net EB (right) of adult goats. The continuous line represents Y = X.

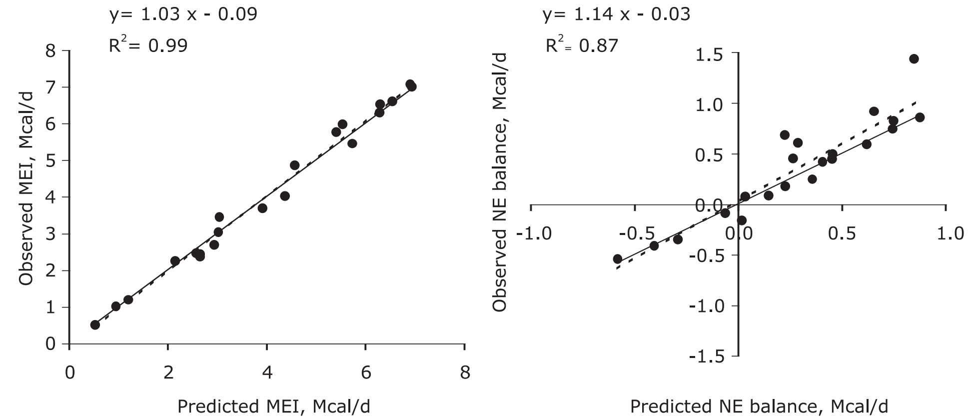
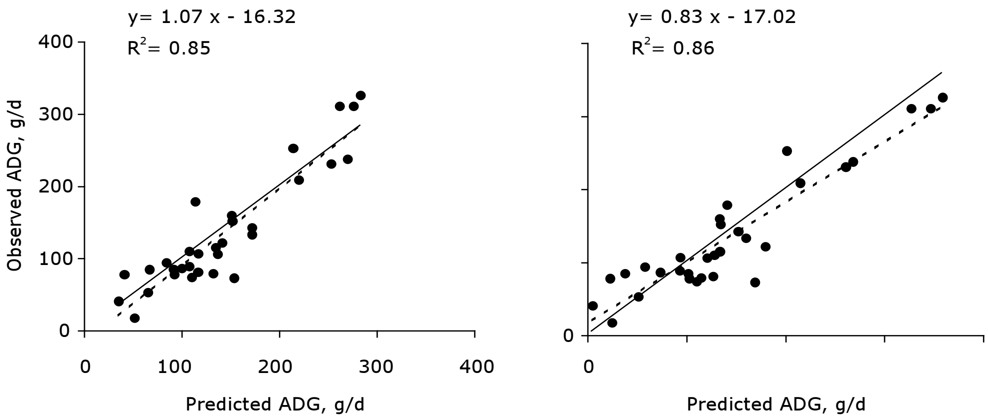


Figure 2. Comparison of average daily gain (ADG) observed and predicted either with the models of SRNS (left) or Luo et al. (2004) (right). The continuous line represents Y = X.



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