Small Ruminant Nutrition System – HELP

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The Small Ruminant Nutrition System (SRNS) is a feeding system, before September 2005 named CNCPS Sheep, derived from the Cornell Net Carbohydrate and Protein System (CNCPS) for cattle (Fox et al., 2003).
A detailed description of the equations used by the SRNS is reported by Cannas et al. (2004), Cannas et al. (2006), Tedeschi et al. (2010).
Updates of the software and more information on the SRNS can be found in the website:
http://www.nutritionmodels.com/srns.html

1. INPUTS

Animal type: category of animals for which the diet is evaluated. Lambs = growing sheep less than 1 year-old. Males have higher (15%) maintenance requirements than ewes or castrated males.

Age: mean age of the group of animals for which the diet is evaluated. It affects energy maintenance requirements, which are decreased by 16% going from 0 to 6 year-old sheep.

Body Weight = current shrunk body weight (SBW) or full body weight (FBW). SBW= 0.96 FBW. It affects requirements for maintenance, body reserves, and feed passage rate. FBW can be predicted for any BCS as follows:
FBW = (0.594 + 0.163 *BCS) * FBW@BCS 2.5
where FBW@BCS 2.5 is the mature weight of ewes of a certain breed, population or flock of ewes at BCS equal to 2.5.

Standard Reference Weight at BCS 2.5 = 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 BCS is 2.5 (FBW@2.5). FBW@BCS 2.5 is used to estimate FBW at any other BCS: FBW = (0.594 + 0.163 *BCS) * FBW@BCS 2.5

Rearranging this equation, it is possible to estimate FBW@BCS2.5 when current BCS and BW are known: FBW@BCS 2.5 = current BW /(0.594 + 0.163 * BCS).

In addition, the ratio between current FBW and FBW@BCS 3.0 determines the composition of gain (% of fat, protein, water, minerals) and thus growth requirements of lambs.

Wool Depth: depth of the wool measured perpendicularly to skin surface. It affects thermo insulation of sheep and therefore cold stress requirements.

Clean Wool Production = production of clean wool per year. It affects MP requirements.

Current Temperature = current mean daily (24 h) air temperature (°C). It affects maintenance requirements for cold stress.

Previous Temperature = previous month average daily air temperature (°C). It affects maintenance requirements because animals adapt to low temperatures (increasing their metabolic rate and requirements) and to high temperatures (decreasing their metabolic rate and requirements).

Wind Speed = measured at ground level, influences resistance to cold (winds reduces wool thermo insulation).

Rainfall = only for sheep kept outdoors. It influences resistance to cold (rainfall reduces wool thermo insulation).

Horizontal distance = daily distance walked by sheep every day on flat surfaces. The minimum horizontal distance can be estimated on the basis of the distance between the farm and the field of pastures. It affects maintenance requirements for movement.

Vertical distance = the vertical component of the movement. It affects maintenance requirements for movement.

BCS = current body condition score, scale 0-5. It affects body fat and protein reserves and the cost of their variation.

Days pregnant = number of days since mating. It determines the stage of pregnancy and affects pregnancy requirements, which are important above all in the last 60 d of pregnancy.

Lamb birth weight = expected lamb birth weight. For lambing with twins or triplets, it is the sum of the BW of all lambs from the same lambing. It affects pregnancy requirements.

Milk production = daily milk yield (predicted or measured). It affects energy requirements of lactation.

Milk fat = measured percentage of fat in the milk for a particular day of lactation. It affects energy requirements of lactation.

Milk true protein = measured percentage of true milk protein for a particular day of lactation. If only total milk CP (N x 6.38) is known, consider milk true protein = 0.95 total milk CP. It affects protein requirements of lactation.

Table 1 – Standard Reference Weights (SRW, kg) for the prediction of the composition of empty body gains for various sheep breeds (from CSIRO, 1990, integrated with other breed values).

Breeds	**Females**	**Castrated**	**Males**
Merino (small, e.g. Saxon), Southdown	40	48	56
Sarda	45		65
Merino (medium), Cormo, Hampshire, Polwarth, Dorset x Merino, Reyland, Comisana, Massese	50	60	70
Border Leicester x Merino, Cheviot Corriedale, Dorset, Drysdale, Romney, Suffolk, Tukidale, Lacaune	55	66	77
Merino (large, e.g. S. Austral.), Border Leicester	60	72	84

2. RATION & REPORT

After inserting the amounts of each feed of the diet, click **RUN COMPUTATIONS AND SHOW REPORT**. To make the runs automatic at each feed change, select, under **TOOLS**, the command **RUNS COMPUTATIONS AUTOMATICALLY**.

Main Feed inputs in the SRNS

Cost	Conc	Forage	DM	NDF	Lignin	CP	SolP	NPN	NDFIP	ADFIP	Starch	Fat	Ash	peNDF
$/tonAF	% DM	% DM	% AF	% DM	% NDF	% DM	% CP	% SOLP	% CP	% CP	% NSC	% DM	% DM	% NDF

- Cost ($/TON AF) → feed cost per ton as fed
- Conc (% DM) → % of concentrate in the feed, usually 100
- Forage (% DM)→ % of forage in the feed, usually 100
- DM (% AF) → DM, as % of as fed
- NDF (% DM)→ feed NDF concentration, % DM
- Lignin (% of NDF) → feed lignin (ADL, % DM) concentration as percent of dietary NDF (% DM) (e.g. if NDF = 45% of DM, Lignin = 5% of DM, Lignin as % of NDF is = 5/45 x 100= 11.1%)
- CP (% DM) = Crude Protein (N*6.25) as % DM
- SolP (% CP) = soluble protein ($A+B_1$), as % of CP;
- NPN (% SOLP) = non protein nitrogen, as % of soluble protein = $A/(A+B_1)$ x 100
- NDFIP (% CP) = CP insoluble in the neutral detergent (i.e. linked to NDF). Sum of B_3+C fractions, as % of CP
- ADFIP (% CP) = CP insoluble in the acid detergent (i.e. linked to ADF). Fraction C, as % of CP
- Starch (% NFC)= starch as % of non-fiber carbohydrates (NFC=100-CP-ash- fat-NDF-NDFIP)
- Fat (% DM) = ether extract as % of DM
- Ash (% DM) = total ashes, as % of DM
- peNDF (% NDF) = physically effective NDF. Percent of total NDF that is retained in sieves with mesh of 1.18 mm or larger. Usually obtained sieving whole feeds and assuming that % of DM above 1.18 equals % of NDF above the same mesh size.

SHEEP RESULTS

ENERGY, PROTEIN AND MINERAL BALANCES

For all categories, the first table calculates energy, protein, Ca and P balance.
Energy balance is estimated as difference between ME intake and ME requirements. The SRNS calculates specific NE requirements for each function. These requirements then are converted to ME using a specific conversion efficiency of ME to NE for each physiological function. The energy available for growth (young sheep) or for body reserves changes (mature ewes or rams) depends on the energy balance.
Regarding MP balance, when it is positive the MP in excess is converted to urea and contributes to urea cost (see PROTEIN).

RUMEN

Rumen pH is predicted as function of the intake of physically effective fiber (peNDF) compared to the required peNDF. The SRNS cannot account for the direct effect of NFC on rumen pH and assumes that TMR diets with frequent meals are used. When pH is low, the model predicts a reduction of degradations rates and microbial efficiency (Tedeschi et al., 2000).

Rumen N balance predicts if rumen bacteria N requirements are satisfied. When rumen N balance is positive, excess nitrogen is excreted as urea and contributes to urea cost (see PROTEIN). When rumen N balance is negative, the SRNS reduces feed digestibility and feed energy compared to diets which induce positive rumen N balance. To maximize intake, feed digestibility and animal performances, rumen N balance should be positive.

PROTEIN

Daily MP intake is the sum of MP derived from escape protein (feed MP) and bacteria proteins (bacteria MP) digested in the intestine. Bacteria MP is usually cheaper and of higher biological value than feed MP, for this reason it should be as high as possible.

Urea cost represents the energetic cost of converting excess N to urea. Excess nitrogen is the sum of rumen N in excess to bacteria needs (see RUMEN) and MP in excess to animal needs (see **ENERGY, PROTEIN AND MINERAL BALANCES)**. Urea cost is added to energy maintenance requirements and therefore has a negative impact to animal performances.

3. BALANCING RATIONS

Many factors determine the ability of the SRNS to accurately predict animal requirements and supply of nutrients to meet requirements in each unique production situation. Because many of the factors (body size, environmental conditions, feed digestion rates, particle size, etc.) depend on field observation, the input factors must be adjusted in a logical way until the model predicts the performance that is being observed before alternatives can accurately be evaluated. This approach allows requirements to be computed for the specific animal, environmental, DMI and feed compositional conditions.

After all of the animal, environmental, feed composition, and dry matter intake inputs requested are entered as accurately as possible, we recommend using the following sequence of steps to have model predicted and observed performance agree in each unique production situation. This hierarchy is necessary, because of the "ripple effect" of all of the interactions in the model (Fox et al., 2003). When one factor is altered, several others will likely be affected.

1. Accurately determine DMI, and compare it to that expected. The accuracy of the SRNS predictions is highly dependent on the DMI used. Intake of each feed must be as uniform as possible over the day, because the SRNS assumes a total mixed ration with steady state conditions. The actual dry matter intake must be accurately determined, taking into account refusals, moisture content of feeds and scale accuracy. Intake prediction is based on requirements, so in optimal environmental conditions and when fiber does not limit intake. Thus, it should be considered as a maximum intake value.

2. Compare predicted change in body condition score, based on diet energy excess or deficiency to that observed. In the case of lactating and dry ewes, the predicted energy balance compared to observed days over which animal condition will change one score is an excellent indicator of the diet energy balance being achieved. Predicted and observed body condition scores should agree. Avoid too fast BCS variations. During early lactation maximum BCS decrease should be 0.75 points in 6 weeks. Energy balance and BCS should start to recover by the end of the second month of lactation

3. Check animal inputs. Mistakes or incorrect judgments about inputs such as body size, milk production and its composition, or environmental conditions are often made.

4. Check feed factors that may be influencing energy derived from the diet as the result of feed compositional changes, and possible effects on digestion and passage rates. The ME derived from forages is most sensitive to NDF amount and % of the NDF that is lignin, available NDF digestion rate, and peNDF value. If the rumen pH is below 6.2, the digestion rate of the cell wall is reduced, based on pH predicted from peNDF. Check the assignment of peNDF; it is used in computing passage rate. If too low, passage rate may be too high, reducing predicted ME value. The major factors influencing energy derived from feeds high in NSC are ruminal and intestinal starch digestion rate. This is mainly a concern when feeding corn and/or corn silage. We adjust this value based on appearance of corn in the manure, using the value ranges provided in the intestinal digestibility help as a guide.

5. Make adjustments to insure effective fiber requirements are being met. In high producing ewes or high energy fed lambs, it is difficult to balance fiber requirements because of the increase in energy density needed to meet energy requirements for maximum production. We make adjustments to insure that diet peNDF is a minimum of 20% in lactating ewes, or growing lambs where forage utilization is important. As much as 25% peNDF may be required to maintain an adequate pH, depending on feeding management. Under low pH conditions (pH below 6) microbial yield will be reduced at least a third by the SRNS, and very little energy will be derived from the fiber in forages fed.

6. Balance the rumen for nitrogen. Feeds such as soybean meal that are high in degradable true protein are added until ruminal peptide needs are met if amino acids are expected to be deficient; they are required for maximizing microbial protein production from nonstructural carbohydrates. Then adjust remaining ruminal nitrogen requirements with feeds high in NPN or soluble protein until total rumen N needs are met. In addition to maximizing microbial amino acids supplied, the total tract digestion of fiber is dependent on the extent of ruminal fermentation. Optimal rumen N balance: 5-10% excess.

7. Balance the animal's metabolizable protein (MP) requirements. This component represents an aggregate of nonessential amino acids and essential amino acids. The MP requirement is determined by the animal type and the milk production. The adequacy of the diet to meet these requirements will depend on microbial protein produced from structural and nonstructural carbohydrate fermentation and feed protein escaping fermentation. If MP balance appears to be unreasonable, we check first the starch (Carbohydrate B1) digestion rates, using the ranges and descriptions in the tables in the feed digestion rates help. Altering the amount of degradable starch will also alter the peptide and total rumen N balance, because of altered microbial growth. Often the most economical way to increase MP supply is to increase microbial protein production by adding highly degradable sources of starch, such as processed grains. Further adjustments are made with feeds high in slowly degraded or rumen escape (bypass) protein (low Protein B2 digestion rates; see the tables in the feed digestion rates help. Optimal MP balance: 5-10% excess. In early lactation (first 3 weeks) it can be slightly negative (max 10% deficit).
Bacterial MP should be 60-65% of total MP, at least, the rest being feed MP (escape protein).

4. INTAKE

Indoors

The SRNS predicts intake based on the equations published by Pulina et al. (1996) (see Cannas et al., 2004), which were estimated for in barn fed sheep. They predict the intake of the sheep that satisfy their energy requirement for diets in which fiber does not limits intake. References values of level of intake and maximum dietary NDF concentrations are reported in Table 3.

The intake prediction of the SRNS for the first month of lactation should be corrected based on NRC (2007):

Days in milk	Reduction factors (to be multiplied by the SRNS predicted intake)
0	0.55
10	0.80
20	0.95
30	1.00

Intake prediction and requirements of pregnant ewes should be based on the BW take at least 1 month before lambing, to avoid overestimations of BW due to fetal and uterus growth.

At pasture

When sheep are fed at pasture, in addition to sheep requirements and dietary fiber other factors are involved, such as pasture biomass and structure, qualitative characteristics and feed supplements. The SRNS does not have equations to predict pasture intake. The following approach, based on experiences on dairy cattle fed at pasture, is suggested to use the SRNS to evaluate pasture diets and identify ways to optimize rumen fermentation, reduce nutrient excretion, and lower feed costs (Ceralosetti et al., 1998):

1. Collect feed input information, including weights of barn-fed feeds and feed analyses. Feed should be reanalyzed upon changes. Pastures should be sampled at least once monthly or upon changes in pasture type. Forage analysis should include CP, NDF, lignin, soluble P, NPN, NDFIP, ADFIP, and ash;

2. Collect necessary animal and environmental information, including BCS (scale 0-5). BCS should be performed monthly on a representative number of animals in each production/stage of lactation group;

3. Asses pasture availability and allowance to determine if animals have enough pasture forage to maximize pasture DMI. Pasture availability (forage mass before grazing) higher than 1.2-1.5 tons/hectare will generally allow maximum DMI (CSIRO, 1990) if pasture allowance is 20-30% higher than pasture allowance needed by each animal.

4. The SRNS should be used to predict current animal performance before adjustments to the diets are evaluated in order to help determine and validate inputs (such as feed intake and environmental inputs);

5. Pasture DMI intake can be estimated by fixing DMI of barn-fed feeds and then varying pasture DMI to meet total predicted DMI and/or until the SRNS predicts measured BCS change. As trends in measured BCS may not reflect energy adequacy of the diets on any given day, the latter method should be not solely relied upon to predict DMI. Where practical, estimations of DM disappearance (pasture DM allowed minus residual pasture DM) might be used to predict herd average pasture DMI;

6. Once current animal performance has been predicted, it is advisable to divide the flock into at least two production groups to evaluate adjustments to the ration, following the steps outlined above (see 3. BALANCING RATIONS)

5. NDF AND NFC

For lactating sheep, optimal dietary concentrations of NDF (and NFC) that maximize forage utilization and do not constraint intake are reported in Table 2. More specific estimates for sheep of different body weight are reported in Table 3.

Table 2. Optimal concentrations of NDF, and NFC depending on the productive levels of the sheep. The estimates refer to sheep with BW of 50 kg (Cannas, 2004; Cannas et al., 2002).

	PRODUCTION CLASSES OF 6.5% FAT CORRECTED MILK YIELD (g/d)					
	< 500	**500–799**	**800-1099**	**1100–1399**	**1400–1699**	**1700–2100**
NDF (% DM)	45.0	45.0	44.5	41.2	38.9	33.2
NFC (% DM)	28.0	28.0	28.0	31.0	33.0	38.0

NFC = 100 - $NDF_{N\text{-free}}$ - CP - EE – ash

Table 3. DM intake of lactating ewes based on energy requirements and NDF dietary concentration above which fibers starts to limit intake, assuming optimal NDF intake is 1.64% of BW (Cannas, 2016; unpublished).

Milk, kg/d 6.5% fat, 5.8% prot.	**40 kg BW**			**60 kg BW**			**80 kg BW**		
	DMI kg/d	**DMI % BW**	**Diet NDF % DM**	**DMI kg/d**	**DMI % BW**	**Diet NDF % DM**	**DMI kg/d**	**DMI % BW**	**Diet NDF % DM**
0.5	1.29	3.23	50.8	1.83	3.05	53.8	2.32	2.90	56.5
1.0	1.62	4.04	40.6	2.15	3.59	45.7	2.65	3.31	49.6
1.5	1.94	4.85	33.8	2.48	4.13	39.7	2.97	3.71	44.2
2.0	2.27	5.67	28.9	2.80	4.67	35.1	3.30	4.12	39.8
2.5	2.59	6.48	25.3	3.13	5.21	31.5	3.62	4.53	36.2
3.0				3.45	5.76	28.5	3.95	4.93	33.2
3.5				3.78	6.30	26.0	4.27	5.34	30.7
4.0							4.60	5.75	28.5

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