LRNS DUAL-PURPOSE COWS TUTORIAL

Much of the milk in the tropics is produced by dual purpose cows. These dual purpose cows are used to harvest nutrients from predominantly grass pastures for the production of milk and meat. Nutritional systems are needed to predict milk production by cows on pastures of varying nutritive value under the prevailing environmental conditions, and to design supplements that will complement available forages to meet production objectives.

Forage quality is one of the greatest limitations to improving cattle productivity in the tropics. Because of its importance, it is important for researchers, educators, and farm advisors to understand the relative impact of variation in carbohydrate and protein fractions in forages on animal production. For this reason, our objective with this case study is to learn how to use Large Ruminant Nutrition System (LRNS) model to evaluate the effect of tropical forage quality on milk production of dual purpose cows. For this case study, we will use the data published by Juarez Lagunes et al. (1999); details of the study and references can be obtained from that paper.

Those using the LRNS often use the feed composition values in its feed library to evaluate diets and develop feeding programs. To compare the effects of using tabular or measured carbohydrate and protein fractions and rates of digestion, we will use the data from these dual purpose cows (described in Table 2) and the actual feeds fed to these cows (Tables 1 and 3). The source of the data and inputs used are summarized below.

Animal and environment inputs: These inputs (Table 2) describe the averages for animals in this study; a mature, mid-lactation, crossbred cow (3/4 Holstein x 1/4 Zebu) in August in the Southeastern Gulf Coast region of Mexico. The climate of the area is tropical sub humid (no month with an average temperature below 18 degrees C and has a dry season). The mean temperature was 25 degrees C and the relative humidity was 81% during the study. The LRNS accounts for these effects on maintenance requirement and predicted DMI. The cows were milked mechanically twice daily and calves were not allowed to suckle. Daily milk production and monthly analyses of fat, protein, and SNF were used to calculate biweekly measurements of milk production and composition for individual cows. Monthly BW was recorded. Changes in BW were calculated as the BW of the current month minus the BW of the previous month.

Feed intake: The month of August was chosen because it is the middle of the rainy season and forage availability does not limit voluntary DMI. The cows rotationally grazed 27 ha Pangola grass (*Digitaria decumbens*). The grazing plots were 1 ha each with cows grazing one plot each day. The plots were allowed to regrow for 27 d between grazing periods. Cows were fed 3.5 kg of concentrates daily (Table 3). Two kilograms were offered in the morning and 1.5 kg were fed in the afternoon. The concentrate mix (DM basis) contained 64% sorghum, 22% soybean meal, 10% cane molasses, 3% mineral mixture, and 1% urea. Because the DMI of the pasture was unknown, a common situation in grazing studies, we determined the forage DMI required to support the observed performance, as described by Perry and Fox (1991). Pasture intake was changed until the predicted (ME intake minus animal requirements, including body weight gain) and observed energy balance (as evidenced by body weight change) agreed.

Feed analysis: Samples of Pangola grass (*Digitaria decumbens*) were collected during August at 28 days of regrowth. These forage samples along with samples of the ingredients included in the concentrate were freeze-dried and sent to Cornell University for analysis. The chemical and in vitro digestion analyses for Pangola grass and the ingredients included in the concentrate are summarized in Table 1, along with tabular values. Most of the measured carbohydrate and protein pool sizes for Pangola grass were similar to the tabular values, except that the measured NPN value was considerably higher than the tabular value. The starch as a proportion of the NSC was higher because the original tabular value was erroneously entered as a percentage of DM instead of as a percentage of NSC. Measured digestion rates for Neutral Detergent Solubles ($A + B_1$ carbohydrate fractions) were lower than the tabular values but the measured digestion rates for the B_2 carbohydrate and B_3 protein fractions were higher. The digestion rates for the B_1 and B_2 protein fractions were not measured.

In this tutorial, we will evaluate the data presented from the performance of the dual purpose cows as a single group for the time the measurements were taken (August). To learn how to evaluate an entire herd for the year, see the **LRNS Large Dairy Herd Tutorial**.

STEP 1. CREATE A NEW SIMULATION

1. Click on ***File***, then ***New Simulation***, from the menu. Name this simulation ***dual purpose tutorial***.
2. Create the animal group (required inputs are in Table 2).
   a. Select ***create animal group***, then select ***lactating cow***, then name the group ***dual purpose cows.*** Then in this same screen (parameters) select the parameters for this group (units = metric, ration basis = DM, energy units = calories, level solution = 2, number in the group = 50, and days to feed = 31; month of August).
   b. Select the default group, then click on ***delete group***.

STEP 2. CREATE A FEED LIBRARY FOR THE FARM

1. Click on the ***feeds*** icon in the top menu bar.
2. Click on ***add feeds*** in the feeds screen.
3. When the feed library screen appears, click on ***tropical feed library.***
4. Select the feeds to be used on this farm (those listed in Table 1 except for the NRC pangola grass; it is not in the feed library) from the feed categories in the feed library screen (grass forages, legume forages, energy concentrates, protein concentrates, etc). Click on the feed as listed in Table 1*; be sure to use those with the indicated IFN number and* ***Mexico*** *at the end of the name.* When you click on the feed, it will be displayed at the bottom of the screen. Check this display at the bottom to make sure you selected the correct ones, based on NDF, lignin and Crude Protein content for forages and the closest feed description for concentrates. If it is not the correct feed, you can de-select the feed by clicking on it where listed in the category list.
5. When finished selecting feeds, select ***add feeds***.
6. Put the feeds in the order listed in Table 1, using the up and down arrows to move the selected feed.
7. ***Save the simulation***.
8. Click on the first ***pangola grass fresh*** in the list of feeds, click on the name in the right column, and change the name to ***Pangola grass measured.***

9. Compare the composition values with those in Table 1 under Pangola grass measured. Values are changed by clicking on the cell to the left of the parameter to be changed (you may have to double click to get a white box, which lets you edit the feed). NOTE: information from feed analysis reports has been organized to be in the units needed for the model. For example, lignin has been changed from % of DM to as % of NDF.
10. ***Save the simulation.***
11. Edit the remaining feeds as for the first feed.
12. ***Save the simulation.***

Table 1. Feed analysis used for evaluating Dual Purpose cattle performance with the LRNS

	Pangola Grass[1]		Sorghum	Soybean	Cane
	NRC[2]	fresh[3]	Grain[3]	Meal[3]	Molasses[3]
		Mexico	Mexico	Mexico	Mexico
IFN #		2-01-668	4-04-383	5-04-600	(only one)
Cost, $/metric ton as fed	3	3	60	250	40
DM, %	21	26.8	87.4	89	85.8
NDF, % of DM	70	69.5	10.3	11.4	0
Lignin, % of NDF	11.4	7.5	12.8	0.9	0
CP, % of DM	9.1	8.9	10.4	52.6	4.2
Solubility, % of CP	42	41.9	14.9	16	98
NPN, % of SolP	4.8	36.3	33	55	100
NDIP[4], % of CP	24	32.5	33.9	5.5	0
ADIP[5], % of CP	2.2	5.4	5	2	0
Fat, % of DM	2.3	2.4	3.6	2	2.2
Ash, % of DM	7.6	8.6	3	7	11.6
Unavailable NDF, % of DM[6]	19.2	12.5	3.2	0.3	0
Avail. NDF, % of DM[7]	48.7	54.1	3.6	8.3	0
NSC, % of DM[8]	13.2	13.5	76.2	29.9	82
Digestion rates, %/hr					
CHOA	250	19.7	14.3	7.9	17.5
CHOB1	30	19.7	14.3	7.9	17.5
Available NDF (CHO B2)	3	5.3	6	5.7	-
B1 protein	135	…	135.02	230.02	350.02
B2 protein	11	…	6.02	11.02	11.02
B3 protein[9]	0.09	5.3	0.122	0.202	0.252

[1] *Digitaria decumbens*.
[2] Tabular values, National Research Council Nutrient Requirements of Beef Cattle (2000).
[3] Laboratory measurements except where noted.
[4] Neutral detergent insoluble protein.
[5] Acid detergent insoluble protein.
[6] Unavailable NDF = NDF – (NDF * lignin (% of NDF) * 2.4).
[7] Available NDF = NDF – (CP *(NDFIP/100)) – unavailable NDF.
[8] NSC = non structural carbohydrate, and is 100 – CP – fat – ash – unavailable NDF – available NDF.
[9] B3 protein = available NDF protein = NDFIP – ADFIP.

STEP 3. DESCRIBE THE ANIMALS AND THEIR FEED INTAKE

Table 2. Animal and environment descriptions

Description	Input Units
Parameters screen:	
Number in group	50 head
Days to feed	31 days
Units	metric
Energy basis	Calorie
Ration basis	dry matter
Ration basis	level 2
Description screen:	
Animal Type	2 Lactating dairy cow
Age	66 mo
Sex	4 cow
Current Weight	511 kg
Mature Weight	550 kg
Body weight	SBW
Breed Type	Beef x dairy (dual purpose)
Days Pregnant	55 d
Days since Calving	174 d
Lactation #	5
Calving interval	12 months
Expected Calf Birth Weight	38 kg
Age at first calving	30 months
Production screen:	
Rolling Herd Average	2866 kg
Milk Production	10 kg
Milk Fat	3.6 %
Milk Protein	3.2 % crude protein
Milk Price	.031 $/l
Condition Score	3 (dairy scale of 1 to 5)
Breeding System	2 way cross
Dam's Breed	Brahman
Sire's Breed	Holstein
Management and Environment screen:	
Additive	None (leave blank)
Added fat	None (leave blank)
Wind Speed	16 kph
Previous Temperature	27 °C
Previous Relative Humidity	81 %
Current Temperature	28 °C
Current relative humidity	81 %
Hours in Sunlight	10 hrs
Storm Exposure	no
Hair Depth	0.6 cm
Mud depth	0

Hide	Thin
Hair Coat	No mud
Cattle Panting	None
Minimum night temperature	20 °C
Activity	Intensive grazing

1. In the tree (displayed on the left), find the ***dual purpose cow*** group. Table 2 contains the information needed to describe the animals and their environment.
2. Click on ***description*** and enter the information requested from Table 2.
3. Then select the next tab at the top of the screen ***(production)*** and use Table 2 to choose or enter the information requested.
4. Then select the next tab ***(management and environment)*** at the top of the screen and use Table 2 to choose or enter the information requested.
5. Then select the next tab ***(ration)*** at the top of the screen and use Table 3 to enter the information requested.

Table 3. Feed intake of case study cows

Diet ingredient	Dry matter intake, kg/day
Sorghum grain (Mexico)	2.24
Soybean meal (Mexico)	0.77
Molasses cane (Mexico)	0.35
Minerals (minvit)	0.10
Urea (in feed byproduct)	0.04
Pangola grass[1] (measured)	7.7
Total	11.2

[1] DMI required to support observed performance.

6. ***Save the simulation***.

Now you can review the results by clicking on ***ration*** under the group name in the tree. You can print out the results for the group by clicking on ***summary results***, then clicking on ***print report.***

Table 4. Performance of dual purpose cows

Actual milk production, kg/day	**10.0**
ME[4] allowable milk, kg/d	10.1
MP allowable milk, kg/d	10.1
Rumen N Balance, g/d	47
Peptide Balance, g/d	60
MP from Bacteria, g/d	610
MP from undegraded feed, g/d	343
Pef balance	-.3
Predicted DMI, kg/day	11.9

Table 4 shows the predicted voluntary DMI was less than the amount of DMI needed to support the observed animal performance (11.2 actual vs. 13.5 kg/d predicted) when actual forage composition and measured digestion rates were used. This result suggests forage availability may have limited

DMI. Milk production was limited to both the MP and MP supply (10.1 kg ME and MP allowable milk vs. 10 kg actual milk/day). Ruminal nitrogen balance was positive; this is important for maximizing fiber digestion as well as microbial yield (the model adjusts both when N is deficient). The peptide balance was positive, indicating maximum microbial yield is obtained from bacteria that ferment nonfiber carbohydrates. Physically effective fiber (Pef) supply was slightly less than the requirement.

STEP 4. EVALUATE THE IMPACT OF VARIATION IN FEED ANALYSIS ON ANIMAL PERFORMANCE

This step demonstrates the importance of having accurate feed analysis.

1. Click on the ***Feeds*** icon in the menu bar at the top of the screen.
2. Click on ***add feeds.***
3. Click on the ***tropical feed library*** in the box at the lower right in the feed library screen.
4. Click on the first ***Pangola grass fresh*** in the grass forages category, then ***add feed***.
5. Click on ***Pangola grass fresh Mexico (IFN 2-01-668)*** in the list of feeds.
6. Change the name to ***Pangola grass tabular***.
7. Change the feed composition values to those listed for library values in Table 1 (first column).
8. Under the group name, click on ***ration.***
9. Enter **0** for ***pangola grass measured*** and 7.7 for ***pangola grass tabular***.
10. Print the ***summary results***.
11. Compare your results to Table 5 values. Note the lower ME and MP allowable milk.
12. **Print the *summary results.***
13. In the ration screen, click on ***define mix.***
14. ***Highlight feeds to go in the mix*** (all except the Pangola grass), then click on **create mix**.
15. Name the mix ***Dual purpose lactating cows.***
16. Click on ***Create mix.*** It will now appear at the bottom of your screen with the total amount of ingredients contained (3.5 kg), and each separate ingredient will show as 0.
17. Click on ***file, save the simulation,*** name it **LRNS *dual purpose tutorial tabular forage.***
18. While keeping total DMI at 11.2, substitute ***mix*** for ***forage*** until the ME allowable milk is equal to the observed milk (forage intake = 5.6and mix =6.6).

Table 5. Expected milk production responses with measured or tabular values

Item	Measured	Library[1]	Library, ME balanced[2]
Actual Milk production, kg/d	10.0	10.0	10.0
ME allowable milk, kg/d	10.1	6.9	10.0
MP allowable milk, kg/d	10.1	8.1	11.4
Rumen N Balance, g/d	47	64	80
Peptide Balance, g/d	60	62	68
MP balance, g/d	4	62	65
MP from Bacteria, g/d	610	509	537
MP from undegraded feed, g/d	343	421	474
Predicted DMI, kg/day	11.9	13.4	13.5
DMI required, kg/day	13.5	11.2	11.2
Cost per day, $.	0.50	0.50	0.70

[1] Forage intake at same level as with measured, but with NRC tabular feed composition values.
[2] Concentrate mix was substituted for forage until ME allowable milk matched actual milk.

Table 5 shows the use of tabular values would have resulted in under predicting milk production from the forage and overfeeding the concentrate mix for 10 kg milk with a higher cost. Although measured and tabular NDF values were nearly identical, the lower concentration of lignin and the higher measured rate of available fiber digestion for the actual forage fed resulted in a higher predicted ruminal degradation of fiber which results in higher microbial yield and higher ME value for the grass.

Evaluating effect of changes in forage composition on milk production

Forage quality is one of the greatest limitations to improving cattle productivity in the tropics. Because of its importance, it is important for researchers, educators, and farm advisors to understand the relative importance of carbohydrate and protein fractions on milk production. Table 6 summarizes the ranges in forage composition measured in 15 species of tropical forages at 35 to 42 days re-growth in the study of Juarez Lagunes et al. (1999). We will now evaluate each of these with our case study cow. The question we are asking is what would be the impact of each of these extremes in value on milk production of our case study cow compared to her observed performance.

Table 6. Ranges in forage carbohydrate and Protein fractions at 35 to 42 days re-growth[1]

Variable	Minimum	Maximum
Feed fraction		
NDF, % of DM	60	80
Lignin, % of NDF	4	8
Crude protein (CP)	4	12
Soluble protein, % of CP	20	50
Digestion rates, %/hr		
CHO A + B1(NDF solubles)	6	26
CHO B2 (Available NDF)	3	9
PROTEIN B3 (NDIP)	4	10

[1]Values were rounded for simplicity of use in this tutorial.

1. Click on ***file, load simulation, dual purpose cows tutorial;*** this retrieves your original file**.**
2. Under feeds in the tree, click on ***Pangola grass measured.***
3. Change the first variable in Table 6 (**Minimum NDF, 60**).
4. Click on ***ration***, and review the results.
5. Compare the results to those in Table 7; correct any errors in inputs.
6. Click on ***summary results***, then ***print.***
7. Click on ***Pangola grass measured,*** and change ***NDF*** to the **Maximum NDF of 80** (column 2, Table 1).
8. Click on ***ration***, and review the results.
9. Compare the results to those in Table 7; correct any errors in inputs.
10. Click on ***summary results***, then ***print.***
11. ***Change the NDF back to the measured value (69.5) shown in column 2, Table 1 .***

12. Repeat steps 2 -11 for the rest of the variables ***(be sure to change back to the original value for lignin(7.5) before evaluating CP, and change CP back to the original (8.9) before evaluating SP***.

Table 7. Expected milk production responses to changes in feed carbohydrate and protein fractions (base is the original base values from Table 4)

	Base	**Min NDF**	**Max NDF**	**Min Lignin**	**Max Lignin**	**Min CP**	**Max CP**	**Min SP**	**Max SP**
ME allowable milk, kg/d	10.1	11.3	8.7	11.3	9.9	10.0	10.0	10.1	10.1
MP balance, g/d	4	48	-70	61	-5	-31	28	40	-10
MP allowable milk, kg/d	10.1	11.0	8.7	11.3	9.9	9.3	10.6	10.9	9.8
Rumen N Balance, g/d	47	42	59	39	48	7	72	41	49
Peptide Balance, g/d	60	47	76	60	60	19	85	63	58
MP from Bacteria, g/d	610	627	563	640	606	647	587	611	611
MP from Undegraded feed, g/d	343	343	345	343	343	276	388	378	330

Balancing the ration

To balance the ration for any of the above, substitute between pangola grass and concentrate ingredients measured as needed to have ME and MP allowable milk to match the actual milk production (10 kg), and to have ruminal N and peptide balances positive, using the following sequence.

a. If ME allowable milk is not close to actual milk, first substitute between pangola grass and sorghum grain until ME allowable and actual milk agree, then substitute between soybean meal and sorghum grain to balance MP and peptides, then adjust urea as needed to balance total ruminal N.
b. If ME allowable milk is close to actual milk but MP allowable milk is not, substitute between soybean meal and sorghum grain to balance MP and peptides, then adjust urea as needed to balance total ruminal N.
c. If only ruminal N is deficient, use urea to balance.

Neutral Detergent Fiber and Lignin. The impacts of NDF and lignin concentrations are summarized in Table 7. The reduced milk production predicted as NDF increased was due to the replacement of NSC with structural carbohydrates (**SC**). The MP from bacteria decreased because there was less rumen degradation of carbohydrates resulting in less microbial growth; this reduced predicted MP allowable milk. Ruminal N balance was positive because of reduced microbial growth. The LRNS calculates unavailable NDF by multiplying the lignin concentration by 2.4 (this factor was evaluated by Traxler et al., 1998) so higher levels of lignin decreased NDF availability. The impact of increased lignin was to reduce available cell wall, which reduced ME available for milk production and microbial yield from cell wall, which reduced MP from bacteria and MP allowable milk. Rumen N balance was positive because of lower microbial growth. Because NDF provides most of the energy in tropical grasses and NDF digestibility is highly variable, it is important to have accurate values for NDF and lignin in tropical forages when fed as a high proportion of the diet to lactating dual purpose cows.

CP and soluble protein. Table 7 also summarizes the results when CP and soluble protein are changed. At the measured protein solubility, as CP increased, the estimated MP allowable milk increased because of an increase in the MP from undegraded feed protein. At the measured forage CP, MP allowable milk production was reduced when the soluble protein percentage was increased. The decrease in MP allowable milk as a result of increased protein solubility resulted from a decrease in MP from undegraded feed protein. However, as more feed protein escapes the rumen undegraded, less degradable protein is available to meet microbial growth requirements. This version of the LRNS reduces NDF digestibility and microbial yield when ruminal N is deficient, using the model published by Tedeschi et al. (2000). If degradable protein equals or exceeds requirement for the carbohydrate allowable microbial growth, additional soluble protein would not be beneficial. An excess of soluble protein will increase energy requirement to excrete excess N (urea cost), which increases maintenance requirement and reduces energy allowable milk production.

Digestion rates of carbohydrates. Table 8 summarizes the results with changing digestion rates to the minimum and maximum measured values shown in Table 6. Predicted ME allowable milk was insensitive to changes in digestion rates of the NSC (A and B_1 ruminal carbohydrate fractions), due to the high intestinal digestibility (75%) assumed for these fractions. The predicted MP allowable milk increased as the digestion rate of the A and B_1 fraction increased because more microbial protein is produced when more NSC is digested in the rumen. With all other values set to those measured (Table 2) the ME allowable milk was very sensitive to change in the rate of digestion of the B_2 carbohydrate fraction. The ME allowable milk increased when the rate increased, due to a greater extent of degradation in the rumen. The predicted MP allowable milk increased as the B_2 rate increased due to greater microbial yield from the cell wall as the extent of ruminal digestion increased.

Table 8. Expected milk production responses to changes in forage digestion rates

	Base	**Min. CHO A+B1**	**Max. CHO A+B1**	**Min. CHO B2**	**Max. CHO B2**	**Min. PROT B3**	**Max. PROT B3**
ME allowable milk, kg/d	10.1	10.0	10.1	8.1	11.6	10.1	10.1
MP balance, g/d	4	-54	17	-136	135	15	-14
MP allowable milk, kg/d	10.1	8.8	10.4	7.0	12.9	10.3	9.7
Rumen N Balance, g/d	47	63	43	73	21	45	51
Peptide Balance, g/d	60	70	57	60	60	58	64
MP from Bacteria, g/d	610	546	624	511	706	611	611
MP from undegraded feed, g/d	343	346	342	343	343	353	323

B_3 protein rates of degradation. Increases in the degradation rates of the B_3 protein fraction for grasses decreased predicted MP allowable milk because less MP was obtained from undegraded feed. Because the rate of digestion of the B_3 protein approximated the passage rate, small changes in either the digestion rate of the B_3 protein or the predicted passage rate had a pronounced effect on the rumen degradability of the B_3 protein fraction. The B_3 protein rates in the original LRNS library rates were much lower (generally less than 0.1%/h) than the measured rates. The original rates result in rumen escape of most of the B_3 protein.

CONCLUSIONS

The results presented show variations in feed carbohydrate and protein fractions and their digestion rates in tropical grasses can have a large effect on milk production of dual purpose cattle. In these evaluations, we assumed the LRNS accurately predicted animal responses to these variations in feed composition, based on previous studies (Lanna et al., 1996). In those studies, the LRNS as described in this paper was evaluated at the University of São Paulo at Piracicaba (Brazil) for accuracy of predictions in tropical conditions with actual DM intake of tropical feeds fed to cattle types typical of those used in the tropics. Feeds were characterized for their content of carbohydrate and protein fractions and their digestion rates. The energy and protein content of empty body weight gain (growing animals) and milk production (dual purpose lactating cows) were measured. The growing cattle data set included 943 Nellore (the most common Zebu breed in Brazil) bulls and steers fed 96 different diets, with a subset of approximately 200 head used to determine composition of weight gain. Average live weight and live weight gain were 337 kg and 0.923 kg/d, respectively. The LRNS accounted for 72% of the variation in live weight gain with only a 2% bias. The lactating cow data set included 18 different diets fed to 178 Zebu crossbred cows representing the wide range in genotypes used for milk production in tropical conditions. The LRNS accounted for 71% of the variation in milk production with a 10% bias. The 10% bias for the lactating cows is believed to be due to difficulty establishing the maintenance requirements of the animals because of the wide variation in their percentage of Holstein and Zebu. The authors observed that accounting for more of the variation in performance with the LRNS would be difficult, because of the lack of uniformity in genotype within Zebu cattle. The authors (Lanna et al., 1996) concluded that the LRNS was more accurate than the NRC under tropical conditions when the feeds and cattle types could be characterized adequately to provide accurate inputs into the LRNS. The LRNS then should provide for a more precise and dynamic estimate of nutrient requirements and animal performance.

Based on these evaluations, we conclude the LRNS can be used to describe animal requirements and the biological values of tropical feeds for cattle typical of those kept in the tropics for developing feeding recommendations, if adequate forage analysis information is available. With tropical grasses, predictions of animal responses are highly dependent on accurate values for NDF, lignin, CP and soluble protein and rates of digestion for the B_2 carbohydrate and B_3 protein fractions.