NORTHEAST SARE 2002 FARMER/GROWER GRANT FINAL REPORT

THE ADAPTATION OF THE CORNELL NET CARBOHYDRATE AND PROTEIN SYSTEM TO NORTHEAST SHEEP DAIRY OPERATIONS

FNE02-421

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2. Restate the goals of your project

The goals of this project were to evaluate the adaptability of the Cornell Net Carbohydrate and Protein System Sheep Model (CNCPS-S) to sheep dairy operations in the northeastern United States. Specific study objectives were to 1) evaluate the use of the CNCPS-S to predict pasture intake, and 2) evaluate the use of the CNCPS to identify supplementation strategies for high-producing dairy ewes.

3. Update information on your farm since you received a farmer/grower grant.

Very little has changed at the Woodcock sheep dairy farm, other then a slight increase in ewes milked. At the time of application approximately 70 ewes were being milked seasonally. During the period in which this project was conducted (summer 2002) approximately 80 ewes were milked. Although there has been talk of expanding the milking parlor to double its current size, this has yet to occur.

4. Who were your cooperators and what were their roles in the project?

The primary technical advisor of this project was Dr. Danny Fox, a Cornell University professor of Animal Science and an authority on the CNCPS. He aided in every aspect of this project, including designing the data collection scheme, model simulations, and post-simulation analysis. Dr. Fox served as the faculty advisor to my senior honors thesis.

Dr. Debbie Cherney, an associate professor of Animal Science at Cornell University, helped specifically with analyzing the results of the destructive sward technique, a technique to measure pasture intake, performed as part of this project. Dr.

Luis Tedeschi, a post-doctorate working with Dr. Fox, aided with CNCPS-S simulations and post-simulation analysis.

This project was performed on the farm of Mark Fischer, and therefore had much to do with the planning and execution of data collection.

Dr. Antonello Cannas, a professor of Animal Science at the Dipartimento Scienze Zootecniche in Sardina, Italy, is an authority on the CNCPS-S, having performed much of the validation of the sheep model. He aided in the design of the data collection scheme, and in post-simulation analysis.

5. Tell us what you actually did in your project and how it was done.

CNCPS inputs were collected during a 3-month period (May 25 to August 25) during the summer 2002 grazing season, on a well-managed 30-acre sheep dairy farm in southern Vermont (43° 14' 24" North, 72° 47' 40" East). The beginning of the collection period coincided with weaning and subsequent onset of parlor milking, which occurred approximately 30 days following lambing. Inputs were collected, on average, once every two-weeks throughout the duration of the collection period.

Fifty-eight ewes, selected on the basis of completing the collection period without being removed from the milking flock for health and/or underproduction reasons, were chosen for this study. Daily milk production was measured using a Waikato goat milk meter (Waikato, Ryde, UK), by summing the milk production of morning and evening milkings (0630 and 1700 h, respectfully). Milk samples were collected upon metering the morning milk production. Samples were stored in 2-bromo-2-nitropropane-1,3 diol at slightly below room temperature until the next available postage day (1 to 2 days). Milk

samples were sent to the Vermont DHI milk testing laboratory (White River Junction, VT; infrared analysis) where milk protein, fat, and somatic cell count were determined.

Ewe body data, including full body weight (BW), body condition score (BCS), and wool depth (WD) was measured at each sample date. Full body weight was measured using a D&S digital farm scale (D&S Farm Equipment, Red Cloud, NE). Body condition score was measured on a scale of 0-5, as outlined by the Sheep Production Handbook (SID, 2001). Wool depth, or length, was measured quantitatively.

Environmental data, including temperature, relative humidity, precipitation, and wind speed and direction were measured during each collection. Temperature and relative humidity were measured using a Hobo Professional Series (HO8-032-08) temperature and relative humidity data logger (Onset Computer Corporation, Bourne, MA). The logger recorded temperature and relative humidity in one-minute intervals, throughout each collection (~24 hours). At the end of each collection trial temperature and relative humidity data was downloaded onto a computer, and the high, low, and average temperature and relative humidity determined. Precipitation during the collection was measured using a rudimentary rain vial. Wind speed and direction were observed at regular intervals throughout each collection.

Paddock area was measured for each collection trial. The distance ewes walked in the 24-hour period (ewe walk), was measured. This was simply the distance from the paddock to parlor multiplied by 4, the number of times each ewe covered that distance each day. This distance did not include walking during period that animals were on pasture.

Dry matter intake was measured in the field using the destructive sward technique as described by Meijs et al. (1982). Seven randomly selected 0.061 m^2 circular-shaped plots within the available paddock (of known dimensions) were cut to ground level prior to grazing. The amount of standing wet herbage from each selected plot was weighed. Dry matter content of the herbage was measured using a microwave oven and scale. A sub-sample (~5 grams), of known weight of herbage was dried in a microwave oven until no weight change (due to evaporating water) was observed. The herbage dry matter content was calculated by:

$$\% \text{ Dry Matter} = (\text{dry weight}/\text{wet weight}) \times 100\%$$

Herbage dry matter standing in each of the cut plots was calculated using the dry matter content and wet weight of cut herbage. These values were averaged, yielding an estimated weight of dry matter available per square meter. Total forage available was calculated by multiplying weight of dry matter available per square meter by the paddock area.

Post-graze cutting plots were not selected randomly, but were collected to the east of, and directly adjacent to pre-grazing plots so the circumferences of the pre- and post-graze cutting plots met at a point. Except for this difference, post-grazing herbage samples were collected and analyzed identically to pre-grazing samples. Total residual herbage left standing following grazing was estimated.

Pasture intake amounts, determined by the destructive sward technique, from the June 28, July 25, and August 17 sample dates grossly underestimated actual pasture

intake. Pasture intake amounts for these three trials were close to zero, and in one case negative. Given the amount and composition of supplementation, as well as ewe milk production during these sample dates, these values were deemed inappropriate as ewes must have consumed pasture to maintain production. This discrepancy highlights the error associated with estimating pasture intake using the destructive sward technique.

To correct for this underestimation the percent of available forage consumed was calculated for May 25, June 8, and August 25 collection dates, in which pasture intake estimated by the destructive sward technique for these trials yielded reasonable intake amounts. Percent of available forage consumed for these three trials was calculated by:

$$\% \text{ Available forage consumed} = \frac{\text{Available Forage} - \text{Residual Forage}}{\text{Available Forage}} \times 100\%$$

The percent of available forage consumed during the May 25 and June 8 sample dates were averaged and applied to the June 28 sample date; the percent of available forage consumed during the July 25 sample date was applied the July 5 sample date; the percent of available forage consumed from the August 25 sample date was applied to the August 17 sample date.

A representative forage sample was collected each trial from the paddock grazed prior to and following grazing. Samples were sent to the Dairy One DHI Forage Testing Laboratory (Dairy One DHI, Ithaca, NY), where they were analyzed for DM (% as fed), CP (% of DM), AP (% of CP), ADICP (% of CP), adjusted CP (% of DM), soluble protein (% of CP), degradable protein (% of CP), NDICP, acid detergent fiber (% of

DM), neutral detergent fiber (% of DM), lignin (% of neutral detergent fiber), NFC, starch (% of DM), fat (% of DM), ash (% of DM), TDN, NEL, NEM, NEG, relative feed value, % calcium, % phosphorous, % magnesium, % potassium, % sodium, % sulfur, PPM iron, PPM zinc, PPM copper, PPM manganese, and PPM molybdenum.

CNCPS model simulations

Summer 2002 inputs as well as several assumed values were entered into the CNCPS Sheep Model Version 1.0.9[®] following the completion of data collection. The study flock was divided into high (>1.71 kg milk day[-1]) and low producing (≤1.71 kg milk day[-1]) groups, each containing 29 ewes, based upon milk production measured at the first collection (May 25). The average milk yield, milk fat, milk protein, BW, BCS, and WD of both respective groups was calculated for each collection trial throughout the summer. Current temperature was calculated by averaging temperature measurements collected by the HOBO Data Logger throughout each respective collection trial. The average temperature calculated for the previous trial was entered as the previous temperature value. Rainfall, wind speed (based on qualitative observation), as well as ewe horizontal and vertical walk of each collection trial were entered into the CNCPS sheep model. An average ewe age of 3.5 years was assigned to both the high and low milk yield groups. This value was based on general flock knowledge. A standard reference body weight of 70 kg and clean wool production of 2.9 kg yr^{-1} was assumed, based upon breed averages (Oklahoma State University, 1996).

Dry matter (% as fed), NDF (% of DM), lignin (% of NDF), CP (% of DM), starch (% of NFC), fat (% of DM), ash (% of DM), soluble protein (% of CP), NDFIP (%

of CP), and ADICP (% of CP) values of the consumed forage were calculated using the principle:

$$(\%Y_{Pre})(SF_{Pre}) = (\%Y_{Post})(SF_{Post}) + (\%Y_{Consumed})(FC)$$

where,

$\%Y$ = percent content of component of interest
SF = weight of standing forage
FC = weight of forage consumed
Pre = pre-grazing
$Post$ = post-grazing

The calculated values of DM (% as fed), NDF (% of DM), lignin (% of NDF), CP (% of DM), starch (% of NFC), fat (% of DM), ash (% of DM), soluble protein (% of CP), NDFIP (% of CP), and ADICP (% of CP) of forage consumed, and the chemical composition of concentrates (from chemical analysis reports) were entered into CNCPS feed composition tables. CNCPS feed library values were used for non-measured feed input requirements.

Average BCS change (body condition scores day^{-1}) observed between trial dates for each group was calculated. Because no BCS and temperature measurements were collected prior to the May 25 collection no calculated BW and BCS changes, or previous temperature values were available for this collection date. Therefore the May 25 collection trial was excluded from model simulation, and BCS and temperature data collected during this trial was used for the June 8 simulations.

One simulation was performed for each milk yield group between the June 8 and August 25 trial dates. Concentrate intake was fixed at 0.8 kg for each trial. Pasture intake was changed manually until the BCS change day^{-1} estimated by the CNCPS-S matched that observed in the high and low milk yield groups. This entered pasture intake was then compared with that measured using the percent available forage and that predicted by CNCPS-S given the animal inputs.

Energy intake was balanced such that consumed metabolizable energy (ME) equaled required ME, by manually changing herbage intake within the CNCPS until this condition was fulfilled. In doing so the first limiting dietary component, ME or metabolizable protein (MP), was determined. Supplementation strategies were suggested to alleviate the dietary inadequacy of the first limiting dietary component, and/or to eliminate excesses in the diet.

6. What were your findings and accomplishments? Did you have any unexpected results? If so what were they?

The results of the destructive sward technique are shown in Figure 1. Of note are the measured pasture intakes of close to zero for the June 28, July 5, and August 17 sample dates. This data highlights the difficulty of measuring pasture intake using destructive sward technique, also described by Mejis (1982). Figure 2 summarizes estimated pasture intake throughout the collection period determined using the percent of available forage consumed principle. Pasture intakes of close to zero were alleviated using the percent consumed technique, however using percent of available forage consumed is an unreliable technique for estimating pasture intake, and therefore the results of this technique must be viewed with caution.

Figure 3 summarizes estimated total DMI (estimated pasture intake plus measured supplement intake) and CNCPS-S predicted DMI for low and high milk yield groups. Predicted DMI differed on average 46.5% and 45.6% throughout the collection period for the low and high milk yield group, respectively. However based upon these results, it is difficult to evaluate the ability of the CNCPS to predict pasture intake, because this project failed to establish a standard measure of pasture intake from which CNCPS-S predicted intake could be evaluated. The percent of available forage consumed technique, used to estimate pasture intake on the June 28, July 5, and August 17 sample dates, is not a reliable technique for estimating pasture intake. Therefore the performance of the model cannot be evaluated.

Given this constraint it was necessary to rely on a recent validation of the CNCPS-S conducted by Cannas (2003), which indicated that the CNCPS-S can be used to predict requirements and feed values for adult lactating ewes.

Metabolizable energy (ME) and protein (MP) balances from the summer 2002, determined by the CNCPS-S given milk yield and environmental conditions, were analyzed. Figure 4 summarizes ME and MP balances for each sample date during the summer 2002. Balances are displayed in ME and MP requirement in excess or deficiency. Both low and high milk groups showed a negative ME and MP balance early in lactation (June 8 and June 28 sample dates, i.e. less then 9 weeks in lactation), followed by a period of positive ME and MP balance (July 5, July 25, and August 17 sample dates). Both groups showed a negative ME and MP balance for the August 25 sample date, associated with a dramatic negative BCS change between this sample date and the previous one. This observed negative BCS change cannot be explained by a lack

of pasture availability (Figure 1), as pasture availability during the August 25 sample date was greater than that measured at the August 17 sample date. Furthermore, the seasonal low milk yield for both groups occurred at the August 25 sample date, suggesting another factor besides pasture availability or milk production resulted in the negative ME and MP balances observed at the August 25 sampling.

The negative MP balance determined by the CNCPS for the August 25 sample date is potentially due to poor forage quality during the period between the August 17 and August 25 sample dates. A seasonal low crude protein content (7.2% of DM) was observed at the August 17 sample date (Figure 5). In agreement with this low protein value, a seasonal high neutral detergent fiber (NDF) and lignin content (66.3% of DM and 7.8% of NDF, respectively) was measured at the August 17 sample date. Forage CP content increased (15.6% of DM), and NDF and lignin decreased (55.6% of DM and 3.5% of NDF, respectively) on the August 25 sample date; however, it cannot be assumed that pasture composition remained constant throughout the period between the August 17 and August 25 sample dates, as the pasture was rotationally grazed. It is likely that ewes were grazed on pasture of comparable poor composition as the August 17 sample date for a several day period between these sample dates, leading to the negative BCS change observed between the August 17 and August 25 sample dates, and the negative MP balance for the August 25 sample date.

Supplementation strategies were formulated using the CNCPS-S to alleviate ME and MP deficiencies and eliminate excesses, by re-simulating data from each sample date and adding energy (whole corn) and protein concentrate (soybean meal) until ME and MP balance (ME and MP requirement equals fed) was fulfilled. The result of this

strategic supplementation plan is summarized in Table I. Ewes in less then 9 weeks of lactation require greater protein supplementation. The CNCPS-S indicated that ewes in the lower milk yield group require greater protein supplementation, which is unexpected when considering this groups lower MP allowable milk requirement. However, the larger MP deficiency observed in the low milk yield group may be a possible explanation for their lower milk production. Ewes of all production levels in greater then 9 weeks in lactation require no protein supplementation to achieve MP balance. Likewise energy supplementation with 0.4 kg of whole corn per day throughout lactation is sufficient to meet ME requirement throughout lactation.

ME and MP balances, and thus the strategic supplementation strategies suggested, are based on CNCPS-S predicted pasture intakes. Therefore supplement recommendations are limited by the accuracy of pasture intake predictions. The supplementation strategy recommended in Table I likely reflects a standard supplementation requirements of lactating ewes on pasture, however they are specific to the animals and conditions present on the case study farm. Furthermore, supplement recommendations are based entirely on achieving ME and MP balance during the summer 2002 grazing season, and may therefore not apply across grazing seasons on the case study farm as environmental and forage conditions are subject to change.

Designing current supplementation strategies with the CNCPS-S

Designing current supplementation strategies with the CNCP-S is possible, however it requires an estimated or predicted pasture intake. In this study CNCPS-S predicted pasture intake was based upon body condition score change from the previous

two to three weeks. Therefore, this estimate may not accurately reflect current pasture intake. A possible technique for predicting pasture intake is the use of pasture intake equations, which account for the major biological variables affecting pasture intake (pasture biomass and composition, body weight, milk fat and protein corrected milk yield). One such equation analyzed in this project, was that developed by Avondo et al. (2002), which predicts pasture intake of lactating dairy ewes. The equation is given by:

<u>For crude protein ≤ 16% of DM:</u>

$$I = 335.6 + 113.5\ B + 0.28\ FPCM - 0.56\ S$$

<u>For crude protein > 16 % DM:</u>

$$Y = 997.2 + 73.9\ B - 27.4\ H + 20.4\ DM + 0.16\ FPCM - 1.24\ S$$

where,

B = biomass (DM hectare^{-1})
FPCM = fat (6.5%) and protein (5.8%) corrected milk yield (gram day^{-1})
S = supplement in protein terms (grams day^{-1} of CP supplemented)
H = pasture height (cm)
DM = pasture dry matter content (%)

This equation was developed by Sardinian researchers based on ten years of research on intake and selection behavior with grazing lactating dairy ewes in the Mediterranean region. Pasture intake for the summer 2002 was calculated using the AVONDO equation, and then compared with other estimates of pasture intake. Results suggest that the AVONDO equation over-predicts pasture intake for spring months (May and June) under-predicts pasture intake during summer months (July and August). This equation was developed based on pasture conditions present in various Mediterranean

systems. Therefore the difference in forage species and composition between the case study farm and the pastures on which the AVONDO model was developed likely accounts or the poor performance of the AVONDO model in this situation.

A potential alternative to avoid measuring or using pasture intake predicting equations is to assume that ewes will consume enough pasture to meet their ME requirement. This condition is likely to be close to achieved, if ample pasture availability is maintained. The CNCPS-S can predict pasture intake given the scenario that ME is in balance. Based upon this pasture intake the status of MP (excess or deficient) can be analyzed and supplements added or removed as needed.

Another alternative is the use of potential intake equations such as that developed by Pulina et al. (1996), shown below:

$$DMI = (-0.545 + 0.095 \times FBW^{0.75} + 0.65 \times FCM + 0.0025 \times FBW_C) \times K$$

where,

FBW = full body weight (kg)
FBW_C = change body weight (grams day^{-1})
FCM = fat corrected milk yield (kg day^{-1})
K = correction factor for pregnant animals; if total birth weight of the litter is more then 4.0 kg, then K is 0.82, 0.90, 0.96, and 1.0 for weeks 1 and 2,3 and 4, 5 and 6, and > 6 after lambing.

This equation was developed for lactating dairy ewes in confinement and represents a maximum possible DMI. This equation can be expected to overestimate intake of ewes on pasture when taking forage availability and grazing behavior into

account. However, when ample pasture availability is maintained, intake should approach the potential intake. Therefore, this potential intake equation may prove useful in operating the CNCPS-S. By setting the pasture intake equal to the calculated potential intake and adding supplements (subtracting supplemented feed from pasture intake) as needed to achieve ME and MP balance, supplementation strategies can be determined. This process assumes that actual DMI will equal potential DMI.

Both of these alternative techniques are limited by the assumptions necessary to perform them. However, by assuring ample pasture availability these techniques become more reliable. It is not possible to design precise diets using these techniques, however they must suffice until further developments in pasture intake equations designed for the northeastern US are made.

7. Did any site conditions specific to your farm and this growing season affect the outcome?

The CNCPS-S takes into account specific environmental conditions. Although this study is quite specific to this case study farm, the CNCPS-S could just as easily and accurately be applied to other site conditions.

8. What were your economic findings, if any?

The results of this project suggest supplementing half as much energy supplement in late lactation (> 9 weeks). Assuming a 16-week lactation, and a whole corn cost of $7 per hundred weight, this would save approximately $37 per head over the course of the lactation. However the increased protein supplement in early lactation would increase feed costs by approximately $60 per head over the course of the lactation. These figures

are based on supplementing with whole corn and soybean meal. Therefore, more economically sound supplementation strategies, using less expensive feeds, are possible. The added returns of balancing MP and ME are difficult to quantify. However, improvement in milk yield, animal health, as well as improved reproduction in the following breeding season could result.

9. Have the results from your project generated new ideas about what is needed to solve the problem you were working on? What would be the next step?

Further developments in the area of pasture intake predicting equations for lactating dairy sheep in the northeastern US are required for the most effective utilization of the CNCPS-S. To be most effective, these equations must be based on easily collected variables that may also be valuable from a management perspective. In this sense giving producers several reasons to invest time and effort into this collection. Until such equations are developed diet evaluation with the CNCPS-S must rely on the two alternatives described above.

The next natural step in this project is to implement the supplement recommendations suggested by this project, and compare observed changes in animal performance to CNCPS-S predicted changes. We would expect animals to be at or near ME and MP balance. However if milk yield were to increase as a result of this new supplementation strategy then ME and MP would not be in balance. A further increase in supplementation would be required to achieve ME and MP balance. Analyzing whether maintaining ME and MP balance is important from a production standpoint would be important in designing future supplementation programs. In other words, evaluating how animal performance responds to varying states of ME and MP balances.

Analyzing the use of the CNCPS-S in a confinement system would test this potential application of the model. Evaluating model performance in diet formulation in confinement systems would be more objective as measured DMI values would be much easier to determine. Such a project would test whether the CNCPS-S is ready for immediate use in such production settings.

10. Will you continue to use the practice you investigated? Why or why not?

I intend to continue researching the practical use of the CNCPS-S for several reasons. The CNCPS-S has great potential for implementation by producers, primarily due to the ease with which the model can be used. The CNCPS-S is formatted in a simple manner, and is comprised of only two interface windows allowing for easy navigation of the CNCPS-S. Furthermore, the CNCPS-S has potential far beyond diet evaluation. Diet evaluation may be of most practical economic use of the CNCPS-S to producers, however the development of the CNCPS in the early-1990's was motivated greatly by the need to manage nutrient excretion into the environment. The CNCPS has been use with great success on many case study farms to reduce the excretion of potentially harmful nutrients. As the sheep industry in the northeast expands, this aspect of the CNCPS-S will become a valuable tool to producers and regulators helping to ensure water quality.

11. Explain what you did in your outreach program.

To date a copy of my honors thesis has been included in the CNCPS-S software, and will be distributed with the program. I am currently designing a tutorial on how to

operate the CNCPS-S that will soon accompany my thesis on the model software. I am currently in the process of contacting extension agents in Vermont and New York, and providing them with a copy of my thesis to determine if there is interest in the results of this project. I have been in contact with members of the Vermont Shepard sheep cheese cooperative. Mark Fischer has expressed interest in presenting the results of this project at the annual Dairy Sheep Symposium, which many sheep dairy producers from the northeast attend. I am dedicated to the distribution of this projects findings, and am confident that these outreach objectives will be achieved.

TYLER HOTALING   **MAY 31, 2002**

WORK CITED

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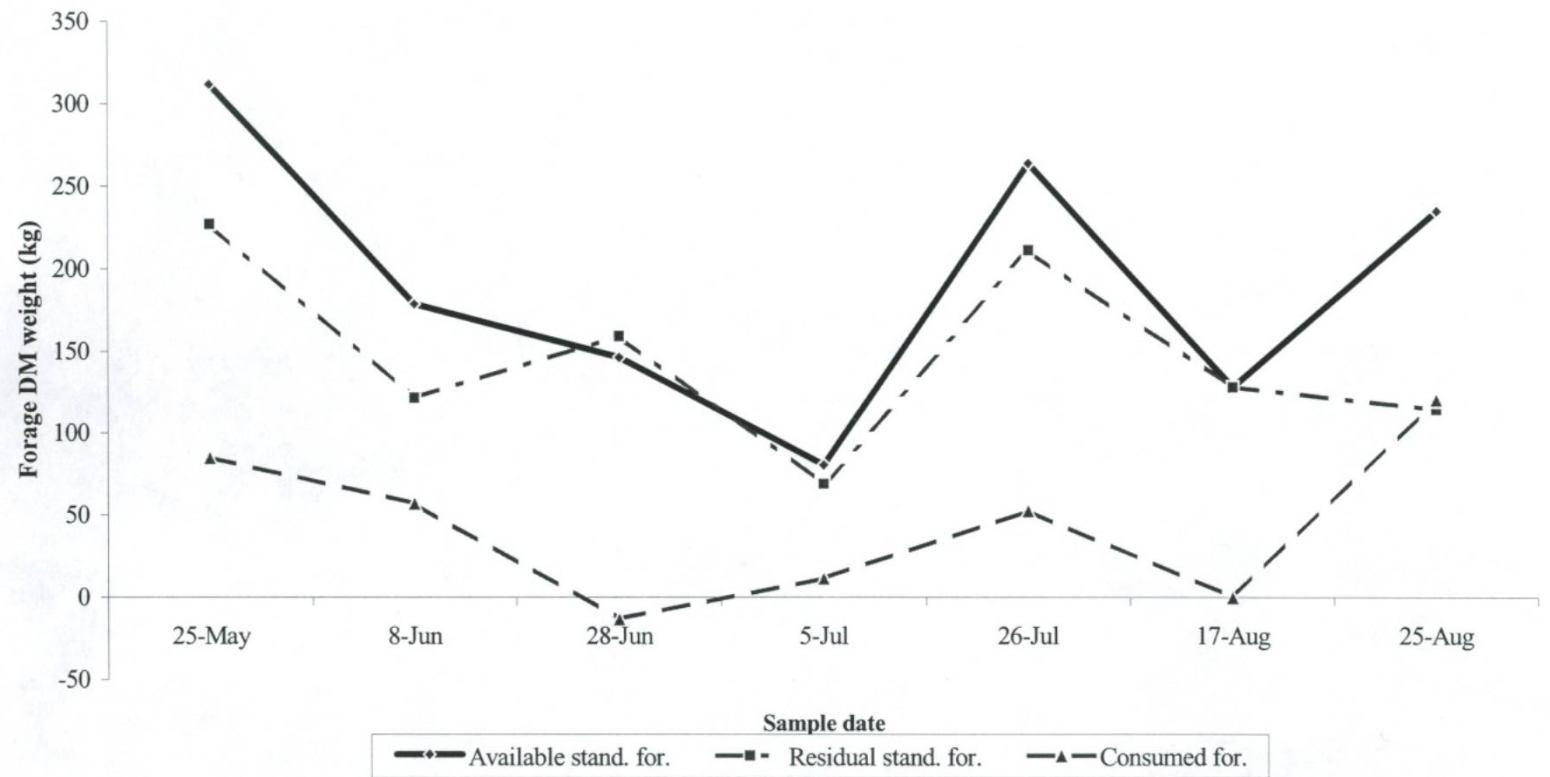
Figure 1. Available standing forage (pre-graze), residual standing forage (post-graze), and consumed forage measured by sward technique by sample date, 2002.
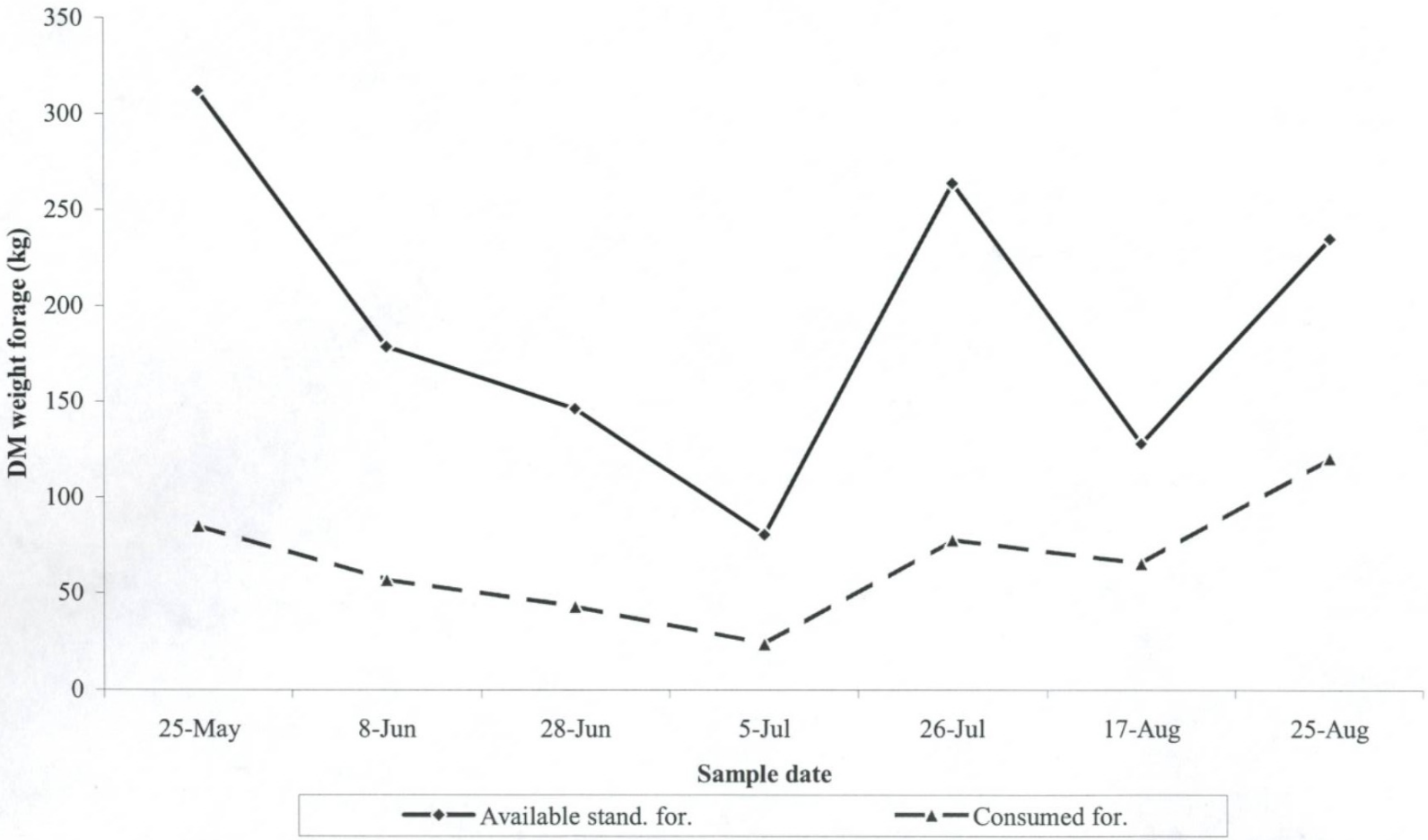
Figure 2. Available standing forage (pre-graze), residual standing forage (post-graze), and consumed forage determined by percent consumption by sample date, 2002.
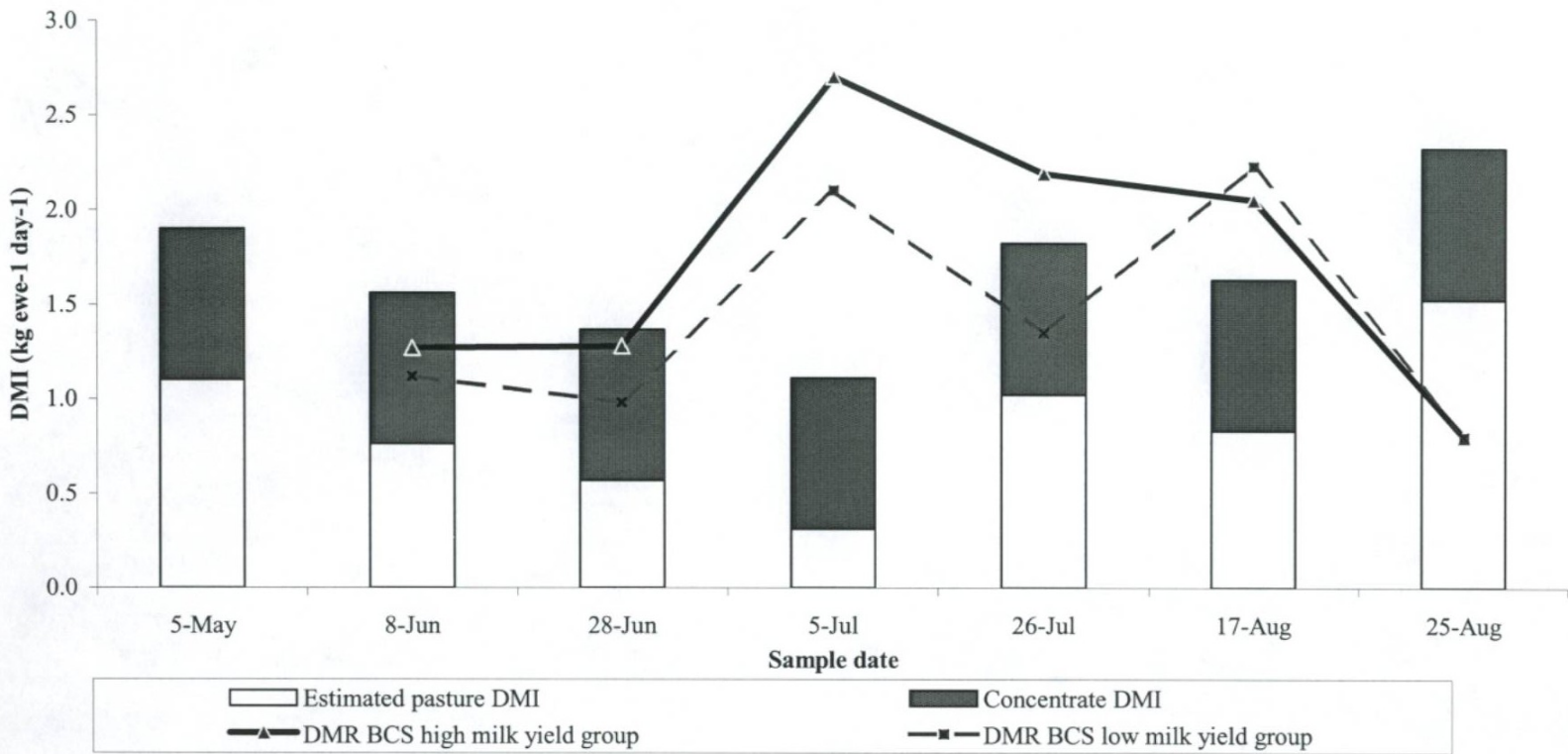
Figure 3. Estimated DMI using percent consumed principle and CNCPS-S predicted DMI by sample date, 2002.
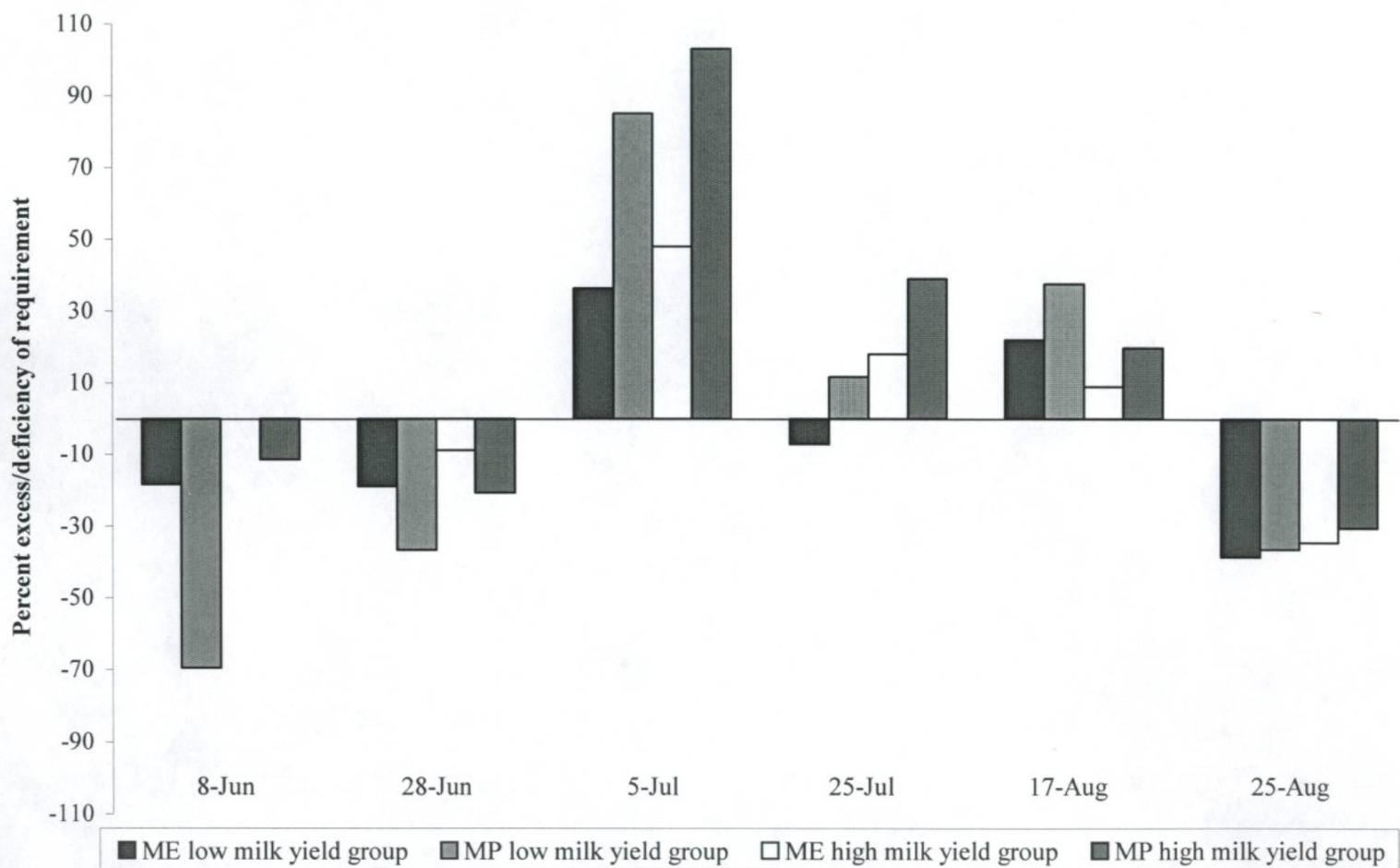
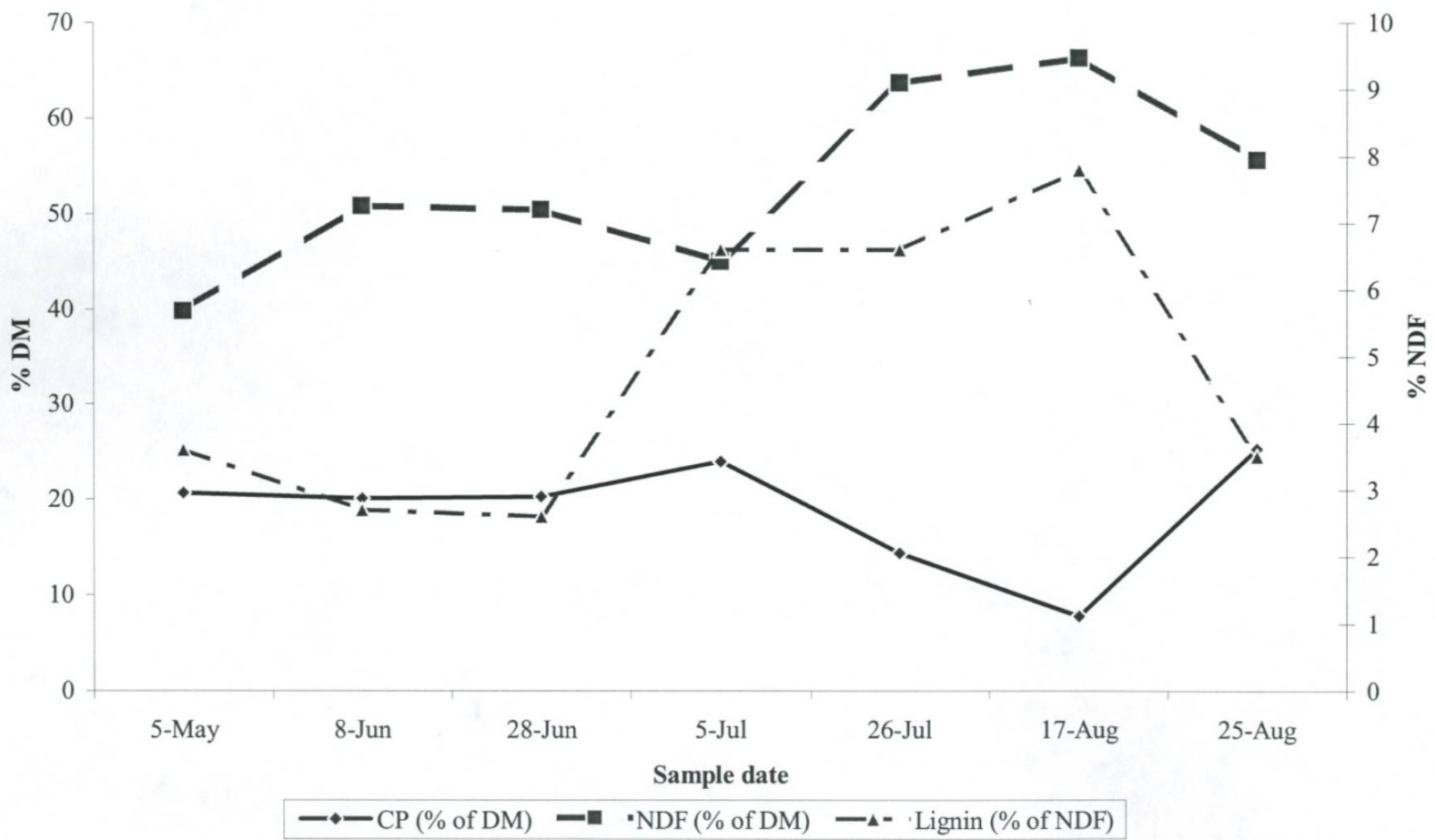**Figure 4. MP and ME balance adjusted for BCS change by sample date, 2002.**

Figure 5. CP(% of DM), NDF(% of DM), and lignin (% of NDF) by sample date, 2002.

Table I: Strategic supplement recommendations for summer 2002 based on CNCPS predictions by stage in lactation.

	WEEK IN LACTATION			
	≤ 5 weeks	6 - 8 weeks	9-10 weeks	≥ 10 weeks
Low milk yield group (<1.71 kg milk day⁻¹)				
Energy conc - whole corn (kg)	0.4	0.4	0.4	0.4
Protein conc. - soybean meal (kg)	0.75	0.65	0	0
Total supplementation (kg)	1.15	1.05	0.4	0.4
High milk yield group (>1.71 kg milk day⁻¹)				
Energy conc - whole corn (kg)	0.4	0.4	0.4	0.4
Protein conc. - soybean meal (kg)	0.4	0.4	0	0
Total supplementation (kg)	0.8	0.8	0.4	0.4