Summary

Since the mid-1990's, the number of commercial dairy goat farms have been on the rise in Vermont and in surrounding states. Many produce their own farmstead cheese but the bulk of the milk produced in Vermont is sold to one, large artisan cheese company. In 2003, at a meeting of farmers who shipped their milk, they all indicated that finding help balancing rations for their goats was a big problem. Most feed companies did not know what advice to give or ignored their inquiries for grain and forage analysis; presumably because the farmers did not buy the volume of grain that dairy cow farms purchased. Only one farmer was using a milk production recording system whose information would greatly assist a feed nutritionist in balancing a diet. Farmers were not used to measuring or keeping track of the dry matter intake, body weights and body scores of their goats. Thus, both parties needed to implement appropriate information and a method for collecting data for ration balancing that optimized production and profitability. If this could be accomplished, the final goal would be to change the behavior of dairy goat farmers and feed company nutritionists to work together.

In this project over 3 years, a total of 13 dairy goat farms were enlisted to work on developing balanced feed rations, in terms of protein and energy, to improve or optimize the diets for the best milk production and feed cost. While there was an online goat nutrient calculator program, there were no well-tested ration balancing software programs to work with that had up-to-date research information. To form the basis for ration formulation, this project provided the following measurements on-farm: monthly individual goat milk production, milk components, milk urea nitrogen (MUN), quarterly goat body weights and condition scores, and feed intake. The PI became the liaison between the farmers and the feed companies and paid for forage analysis when the feed companies did not provide that service. Preliminary farm data was

collected in the first part of year one when the project's ruminant nutritionist, originally written into the project, was no longer available. In year two of data collection, 8 farms worked with a skilled ruminant nutritionist from one feed company and custom feed rations were formulated and applied to the farms based on milk production, dry matter intake, goat weight and condition and feed analysis. By the end of the study, many farmers have continued working with a feed nutritionist and one still pays for a milk recording service. During the period of the study, resources to aid in calculating appropriate rations were looked at including the Langston University's [E Kika de la Garza Institute for Goat Research] Goat Nutrient Calculator (LUGNC), http://www.luresext.edu/goats/research/nutr_calc.htm, and the Small Ruminant Nutrition System (SRNS) which launched its preliminary goat module in 2008 (and is based on the Cornell Net Carbohydrate and Protein System –CNCPS- mathematical modeling programs) http://nutritionmodels.tamu.edu/srns.htm. In addition to this, at the project's close, guidelines for suggested levels of CP, undegradable protein, starch and sugar, ADF, NDF, Fat, Ca, Ph, Mg, Se, Vitamin E were developed and applied using more of a NSC (Nonstructural carbohydrate) approach to nutrient balancing.

Introduction

Demand for dairy goat products in Vermont continues to outstrip the state milk supply as noted by Vermont farmstead cheese makers and the largest Vermont artisan goat cheese company which purchases from 20 goat dairies. One barrier to profitable milk production is high feed costs, accounting for 55-65% of total production costs. The goat's physiology differs from cows in that the dairy goats' dry matter intake (DMI) is much higher per pound of body weight than that of dairy cows (5.5% vs. 3.5% DMI/BW). To accomplish this high intake level to meet their higher energy needs per pound of body weight, goats are able to select the most nutritious

parts of plants and harvested feed and concentrates offered to them. This means they are able to function on a higher concentrate to forage ratio than cows, thus making their diet more expensive. Their higher intake also means a higher rate of passage and potential lowered digestibility that comes with faster passage rates. Most feed manufacturers serving goat dairies have been unable to formulate appropriate rations for dairy goat farms because of a lack of readily available goat nutrient software programs. The goat's physiological and intake behavior differences run counter to the standard practical assumptions and mathematical modeling on which dairy cow ration programs are based. Goats are still ruminants, however, and some proven feeding strategies that feed companies use for cows will work with goats. These feed companies were, for the most part, unmotivated to invest time and resources into serving goat dairies because the volume of concentrate purchased was low as compared to cow dairies. Nutrient requirements for goats were published by the US National Research Council (NRC) in 1982 and were only recently updated recently, in 2008, and await incorporation into a useful software nutrient balancing software package (UC Davis is developing such a software program and it is slated for release February 2009; CAPRICORN WIN08) http://animalscience.ucdavis.edu/extension/software/capricorn). A couple other software or online nutrient calculator programs mentioned above) became available during the study and were evaluated.

Farmers making cheese or shipping fluid milk are rewarded financially by milk protein content, and often feed high nitrogen(N) rations in hopes that they will maximize their milk protein. Feeding improperly balanced N causes wasted N in the form of high milk and blood urea N (MUN/BUN), and ultimately high N urine which contributes to high levels of ammonia volatilization into the environment. At the same time, over feeding N also decreases milk

production as more energy is needed to remove excess N which robs energy from the goat to produce milk. While an MUN range of 12-19 mg/dl is purportedly the ideal range for protein digestion, the relationship between MUN and protein intake is much weaker than in cows and sheep. We still wanted to see if MUN values were a useful assessment tool for goats' diets on Vermont farms.

In this study, we not only wanted to change the behavior of farmers and feed company representatives, we hoped to see correlations between grain fed, grain cost, protein fed, MUN, body weight, body scores and milk yield, fate yield and protein yield. It would also be useful to measure actual milk production over a long period of time as milk production measurement was rare on commercial dairy goat farms in Vermont and in the region. In the final year of the study, the distribution of farms included 6 grazing/browsing herds during the growing season and their milk production curves are a unique data set to share.

Objectives/Performance Targets

Performance Target 1: From a pool of 21 dairy goat farmers in Vermont, 10 will participate in the project and adopt recommended nutrition programs that are more profitable, improve milk production and utilize nutrients better for their improved sustainability.

Year 1: Nine Farms enlisted and began data collection in July and August of 2004. Many dried off their goats in December and 1 farm was dropped from the study. To enlist farmers, we advertised in the Small Ruminant Dairy Project Newsletter that reached all the commercial goat dairy farms in Vermont and the environs. From that, we interviewed and signed up 9 commercial dairy goat operations ranging in size from 30 – 200 milking does. Once the farmers filled out and signed a form of understanding and gave us their financial and production data

from the previous year, we started a schedule of once per month milk weighing and sampling and once per month body weights and condition scoring. Data collection started August 2004. As time ensued, it became clear that financial data from a previous year was not useful in comparing any changes in production or profitability because there are many factors like stored forage quality, weather during the pasture season and fluctuating prices of grain that influence milk production and cost of production.

Ads for a technician were placed in local papers and we hired 2 technicians to split the territory which ranged over 4 counties in Vermont. The technicians were trained and were of high quality. Looking back, it would have been better to hire just one technician in order to offer that one closer to full-time work and be able to retain them throughout the study. Each technician would have preferred more work and finding conscientious and trainable employees was a challenge after they left.

An advisory committee of the PI, ruminant nutritionist, technicians, VT Dairy Herd Improvement Association (DHIA) representative and 2 feed company representatives met before we started collecting farm data and once again a month after the collection started. We were working with 6 feed companies across all the 9 farms. It was slow to get the feed representatives involved to take feed samples for us as part of their normal service. While the project was probably funded because we were targeting 8-10 farms, a smaller study with 4-5 farms would have given better data because conditions were changing constantly and it was time consuming to chase after the feed company representatives and to encourage the discouraged farmers to keep calling them. Once forage and grain nutrient analysis were completed and farm data averaged, evaluations of the metabolizable protein and energy intake and requirements were done by ruminant nutritionist, Dr. Joanne Knapp of the University of Vermont Department of

Animal Science. Letters were sent to all the farms making recommendations for any changes, if necessary, and a multiple of options were offered. Some farms were right on target and others were over feeding protein and one was underfeeding protein.

After a follow up phone call, 4 of the 8 farmers made changes either in amounts of concentrate fed or the % crude protein in their concentrate and lowered their feed costs. This was the case in the months leading up to December 2004. Dr. Knapp left the employ of the University at that time and we decided to continue on-farm measurements while looking for a new small ruminant nutritionist to replace Knapp. This proved harder than imagined. We did not want to lose the data from the farms or lose the technicians by stopping the study so we continued on into the fall of 2005 after which most farms dried off. The search for a ruminant nutritionist was limited to researchers as it was felt that their interest in the outcome would be neutral or unbiased. It may have been better to cast the net to a wider pool of nutritionist in the private sector when it became clear that a university researcher with the time available was near impossible to find. We did get a verbal agreement from a nutritionist from another university in June 2005 but in October, after having done no work on the farm data sent to him, he withdrew his intention to participate. Thus, during 2005 (still the first year of the study), there was little ration balancing occurring although the PI did use the Langston University (E Kika de la Garza Institute on Goat Research) Goat Nutrient Calculator to give some advice on rations. At that time, it was learned that this online program was deficient in accurate milk production data because of small database and the required inputs were based on many assumptions and calculations necessary before a result was obtained. It did not take the place of a nutritionist nor was easy to use by a farmer.

Target 1 Assessment: In the project's second year, 8 of the 10 farms will continue implementing the original study. A follow-up debriefing visit with the farmers and feed consultants after 2 years will provide a personal summation and written evaluation of the success and usefulness of the information. Comparison of data collected during the study including feed costs and milk production from years previous to the study will add determination of its success.

The original projection was that 10 farms would participate in year one (2004-2005) and drop to 8 farms in year two. In actuality, there were 9 farms in year one and 10 farms signed on in 2006 to start measurements again in 2007. Of the 10 farms that signed on, 2 were dropped and 8 finished the study and were reported on. A total of 13 different farms participated in some capacity.

The goal of giving monthly ration balancing information to each farm where data was collected (some farms were seasonal and totally dry during winter months) in the first year was not met due to significant delays in getting feed samples and losing the collaboration of the co-PI ruminant nutritionist. Data collection continued even with the hiring and training of two new technicians to replace the first two that metered the milk, collected milk samples for analysis, measured body weights and body condition scores of the goats and summarized feed programs that the goats consumed. In 2005, after meeting twice with the advisory group consisting of representatives from the Vermont Dairy Herd Improvement Association (VTDHIA), Vermont Butter and Cheese Company (major purchaser of fluid milk), Poulin Grain and Cargill/Nutrena (grain companies) and the farmers participating in the study, we decided to put the study on hold. When it was resumed, we would change the methods in the following ways:

-Milk metering and sampling would be contracted to VTDHIA.

-PI will gather feed and goat body data.

-A new ruminant nutritionist will be contracted with a signed agreement before the study resumed.

Even with the challenges facing the study, progress was made and lessons learned in order to continue the study in a more practical fashion. Because financial resources were conserved in the first year, the study was able to get an extension to fulfill the original goals. The new plan would improve the outcome for the following reasons. Shifting the milk data collection to VT DHIA will, in effect, moved the farmers closer to contracting with VTDHIA to continue milk sampling after the study is over. With the PI gathering goat and feed information directly, this would prevent any delay in receiving the data important for timely ration balancing recommendations. In the beginning, the farmers bought grain from 6 different feed companies. Gains were made to get the representative from the feed companies to provide forage analysis which is not always easily obtained. From the interaction the PI has had with feed company representatives and owners, there was more interest in providing the services that feed companies provide to dairy cow farmers. Plus, some of them have begun to compete for the business of the goat dairies which was unheard of in the past.

While no data was collected in 2006, the search for a ruminant nutritionist partner was consummated with the addition of Dr. Matthew Waldron, a new hire in the University of Vermont's Department of Animal Science. He not only brought graduate study focus on ruminant nutrition but years of professional work in the feed industry. The second element of base for this study was also progressed by the invitation and visitation of Dr. Antonello Cannas, Professor of Animal Science, University of Sassari, Sardinia, Italy. The combination of his

graduate small ruminant research at Cornell University with the collaboration of other researchers has sprung forth a small ruminant nutrition program that is being updated to complement the sheep portion with a goat portion. Dr. Cannas met with Dr. Waldron and gave 4 seminars around Vermont in October 2006 on goat and sheep nutrition. This project plans to utilize this free nutrition program and invite the advice of Dr. Cannas in our study resumed. (See http://nutritionmodels.tamu.edu/sms/index.htm). Unfortunately, Dr. Waldron also left the employ of the University. Although he did work through some rations, he did not find the SNRS to be very useful.

The project resumed in 2007 and 9 farms were recruited/re-recruited to participate in the continued study in 2007. Two farms were dropped and a new one added later giving a final total of 8 farms. We were able to hire a new consultant who was working for a feed company and had interest and experience with dairy goat feeding programs. He developed nutrient recommended guidelines that he applied to the farms on the study.

Performance Target 2: In the Northeast region, 3 feed companies and all 12 state extension programs will adopt the improved goat nutrition information and recommendations for use in their states. This will provide more consistent dairy goat nutrition recommendations and allow more support to those choosing family-friendly, diversified, small-farm goat operations.

Since we were not able to match the data collected with actual increases in production or decreases in grain fed or grain cost, we feel we are only at the start of proving that these nutrient recommendations for lactating goats are universal. These nutrient level recommendations have been shared in presentations at NY State to goat breeder meetings and they are being incorporated in a chapter of "A Guide to Starting a Commercial Dairy Goat Farm" slated for

publication in 2009. It will become available in that form. Even though the study concluded, we will still find ways to share the results in dairy goat and farming magazines.

We did look at the Small Ruminant Nutrient System (SRNS) developed by Canans, Fox and Tedeshi and evaluated it. The SRNS looks to be a true modeling program with no ability to optimize or generate a ration based off of preset specifications defined by the user. We did like that the program was easy to use and one could input feed, intake and production data and get a nutrient profile. The results were agreed closely to the recommendations made in this study. But, it is not set up to balance a ration on its own. Rations can be built in this system absolutely but it would take a trained nutritionist to know what to feed of each ingredient to work through a diet with ease. We envision that this program can be used on-farm by the producer to better understand what the goats are consuming, what nutrients (protein and energy) the goats are getting and thus, possibly help to trouble shoot issues. This program does have some value for sure but does not give a clearly defined milk production predictor. It is a good way to cross reference or check diets and uses a popular modeling system that the Langston University Goat Nutrient Calculator (LUGNC) does not.

The LUGNC program is free online to use by researchers or farmers. It is easy to use and early in this project, it was the only up to date ration balancing program for goats available. It does a good job presenting the protein requirements of goats. We did not find that it gave recommended levels of undegradable protein. The energy system it uses is based upon knowing the energy content of the diet, which is always a rough estimate even if all the ingredients of the diet are analyzed and calculated because these calculations are based on just a few data sets. Also the energy values provided to farmers on feed analysis reports, are based on cow data sets. There are no recommended levels of non-structural carbohydrates(NSC) (i.e. starches and

sugars) in the LUGNC program; knowledge of the diet's NSCs are of immense use matching the digestibility of the carbohydrates with the protein fraction.

Target Assessment 2: Information from this study will be placed on a website and reported in the Small Ruminant Dairy Newsletter. If appropriate, the Langston University's goat website will be promoted to provide the nutrient requirement tables, if available. Otherwise, a Nutrition Program/Nutrient Requirements printed in Excel™ with a fact sheet will be sent to NE State extension contacts and feed company nutritionists with offers to present at annual meetings and conferences. Those receiving the information will be surveyed to assess the use and barriers to its use.

The nutrient recommendations used on goat dairies at the end of the project are presented here in hopes that other nutritionists will try them and find success. The PI and nutritionist consultant are planning to find appropriate venues in the future for presentations on these results. The PI will be attending the 2009 JAM of ADSA-ASAS-CSAS in July in Montréal, QC, Canada and will share goat nutrition handouts there.

Materials and Methods

Year 1: April 2004-December 2004 Technicians hired to meter milk production from individual goats and sample milk for fat, protein, Somatic Cell Count (SCC) and MUN monthly. Quarterly lactating goats in herd were weighed on portable scales and body condition scored by trained technicians. PI collected feed and production information; milk and goat data was entered into spreadsheets by office staff. Feed intake and feed analysis data was coordinated by PI. Data collection began in July/August 2004. Summarized farm data was given to co-PI nutritionist to make ration recommendations. Data used was:

average daily milk production

average fat and protein % and MUN of milk

average weight and body score of goats

average forage and concentrate intake of goats

nutrient analysis of feeds

Notes on specific farm situation (pasture vs. confinement), anticipated change in feed (summer to fall stored feed), health issues with goats and goals of farmers. The nutritionist sent letters to farmers summarizing feed situation and making recommendations. This occurred only once or twice in the fall of 2004 as the nutritionist left in December 2004. Data collection continued on year round milking farms and at next kidding in the spring of 2005 in order to retain the commitment of the farmers and to retain the experienced technicians when a new nutritionist was hired.

Year 1 continued: April 2005 – October 2005. Data collection continued and a nutritionist was found but never followed through. Two new technicians were hired as the original technicians decided to follow more full-time employment. The study was put on hold in October 2005 after meetings with the advisory group. The advisory meetings with farmers summarized the activities and, after input, new methods were approved for when the study resumed. They were:

-contract with VT DHIA to do all the milk metering and sampling and provide the reporting

Year 2: Spring 2007-Spring 2008. The study was resumed with 8 dairy goat farms with the same data collection. VTDHIA did the milk recording, sampling and analysis. The PI collected goat and feed intake data. A new nutritionist was hired.

Results and Discussion

During the first part of year 1, from August to December 2004, the 8 participating farms did receive ration evaluations and recommendations from the nutritionist. All herds were composed of crossbreeds and grade Alpines, Saanen, LaManchas, Nubians, and Oberhaslis. After a follow up phone call, 4 of the 8 farmers made changes either in amounts of concentrate fed or the % crude protein in their concentrate and lowered their feed costs.

What we did see, using the LUGNC and the application of handout developed by Dr. Knapp, was that most farms fed an excess of protein in the diet each time we looked at their current diets (10/13 or 76.9%); only one farm was underfeeding protein (1/13 or 7.7%) and two farms were feeding in the right ballpark of needed protein (2/13 or 15.4%) in Table 1. This confirmed our original premise that most farms erred on feeding more protein in what we believed was their hope of maximizing protein in the milk for their highest cheese yield or milk payment. Unfortunately, feeding a lot of extra protein depresses milk production because of the extra energy needed to rid the body of excess N.

Table 1: Dairy Goat Farm ration evaluations in 2004 with general recommended changes.

Evaluation of diets: # of analyses done	avg daily lbs of milk	mg/dl	YES or NO				
%CP in conc./forage source	Milk	MUN	excess protein	deficient in protein	excess in energy	deficient in energy	Recommended change
14 no soy/pasture	4	16	Y				↓%CP grain
14.5/past+browse	8	17	Y		X		top dress pro
16/past+browse	3.5	18	Y				↓%CP grain
16.5/past+hay	7	17	Y				↓ grain
14.5/hay	4	18	Y		X		↓ grain
20/past+hay	7	25	Y				↓%CP grain
13.6/hay	6.4	9	N	X		X	↑grain/hay
16/pasture	4.75	16	N				no change
13/pasture	3.2	17	Y		X		↑forage
13/hay	3.35	11	Y			X	↑grain
14/past+haylage	2.9	19	~		~		↓ grain↑forage
17.3/haylage	3.2	17	Y		X		↓%CP grain
16.1/past+hay	5.23	17	Y				↓ grain↓CP%

From the data collected in from August 2004 to the end of 2005 (Table 2) , we did not find that the amount of grain fed, the % crude protein in the grain, the MUN levels, the body weight(BW) or body condition scores(BCS) were predictors of milk, protein or fat yield, after applying statistical analysis(Table 3). From this, one could infer that the nutrients provided by the grain did not match the needs of the goat in addition to the forage the goat was eating. So, at the start of this project, feeding goats more grain did not necessarily produce more milk yield. The only predictors of milk, protein and fat yield were those same variables. Since the dairy goat farmers did not continue to receive ration formulation support after the first few months of the study, these results were a reflection of the state of affairs that formed the motivation for this project.

Table 2: Average milk and goat body data collected in year 1 from 8 dairy goat farms.

Farm	Milk (lb/d)	milk fat %	milk prt %	MUN (mg/dl)	SC score	BW (lb)	BCS	Grain fed	%CP in grain
Farm A	3.51	4.49	3.34	15.73	4.23	115.08	2.99	2.75	0.150
Farm B	5.70	3.85	2.94	17.17	5.75	100.08	2.30	2.11	0.148
Farm C	4.09	3.71	3.07	20.17	4.32	123.56	2.94	3.58	0.150
Farm E	6.40	3.81	2.99	13.04	5.27	133.53	3.10	2.75	0.150
Farm F	4.62	4.09	3.35	16.69	5.37	129.80	2.79	.	.
Farm G	5.02	4.34	3.30	22.76	6.08	124.75	2.93	2.84	0.200
Farm H	6.28	4.32	3.38	15.17	6.00	112.78	2.80	2.88	0.188
Farm I	6.16	4.11	2.91	16.02	4.58	132.35	2.87	3.75	0.128

Table 3: Correlations among milk, protein and fat yield, goat body weight, amount of grain(concentrate) fed % CP in the grain (concentrate) in year 1

	Fat Yield	Protein Yield	MUN	BW	BCS	Grain fed	%CP
Daily milk yield	.95**	.94**	-0.42	0.09	-0.17	-0.08	0.01
Daily fat yield	-	.96**	-0.38	0.05	-0.12	-0.08	0.18
Daily protein yield	.96**	-	0.11	-0.11	0.23	-0.14	0.63

******Pearson correlation coefficients that indicate statistical significance.

The project resumed in the spring of 2007 and milk data was collected from that time through the winter of 2007/2008. Kevin Kouri joined the project as the ruminant nutritionist and applied his method of balancing rations which was different from the protein and energy based system we used from Langston University when the study first began. Mr. Kouri had already been working with 2 goat dairies; one was a pasture/browse based seasonal dairy and the other was a Total mixed ration (TMR) year round confinement dairy. He had attended the workshop by Dr. Antonello Cannas to learn more about the specifics of goat intake, production and physiology. He then applied what was working nutritionally for these 2 dairies as stated next:

The largest area of focus that was put on dairy goat rations in this study was in balancing the non-structural carbohydrates, starch and sugars, along with proper fiber levels and protein sources. Assessing proper energy levels with conventional net energy lactation values is outdated and attention should be turned towards non-structural carbohydrate (NSC) values.

Starch levels should be between 15 to 20% while sugar levels should be balanced between 4 to 6%. Therefore, forage analysis that provides starch and sugar values are necessary. Struggling milk production woes typically can be addressed or corrected here. Typical findings during most herds' ration work ups in this study showed that NSC was high due to lack of forage analysis, additional grain was fed in hopes of milk production to follow or that goats were not consuming forage as required. Most on-farm scenarios presented an imbalance of NSC in the rumen, which will tend to develop into acidosis or improper hind gut fermentation due to improper diet balancing or lack of consumed fiber. Limiting feed sorting is paramount for all ruminants and in dairy goats this is a big challenge. The goal here is to feed higher levels of forage first then supplement appropriately with concentrate on a dry matter basis.

Recommendations for crude protein are between 15-16% (DM basis) but focus must include looking at the undegradable and degradable protein fractions. Excess protein feeding was observed to be the norm in most cases, with most of the protein being feed in excess as degradable protein. Feeding less degradable protein, a range of 4 to 6%, and supplying more protein to the hindgut as undegradable protein, 10 to 13%, can correct imbalances.

Mineral and vitamin recommendations should not be a challenge to achieve with formulated concentrates. Adequate calcium (.7 to .8%), phosphorous (.3 to .4%) and magnesium (.1 to .2%) should be delivered through most standard mineral packs. Balancing vitamin E and Selenium higher than required was not a problem and beneficial, .3 parts per million (ppm) for Selenium and 30 ppm for vitamin E.

Understanding what each ingredient in the ration provides to the overall nutrient composition of the diet is important. Commonly, feed concentrates for protein are soybean meal,

canola, distillers and heat treated soybean. Soybean and canola are protein sources that are used in the rumen, being labeled as rumen degradable, while products like distillers and heat treated soybean typically escape absorption in the rumen and get used in the small intestine, labeled rumen undegradable. Energy sources, such as corn meal, wheat midds, beet or citrus pulp, molasses, tallow, and bakery waste supply a wide range of energy sources. Soluble fiber is mostly supplied by citrus and beet pulp. Categorizing energy sources into starch source and sugar source should be the main focus. Most forage sources can provide both energy and protein based on their analysis along with meeting fiber needs to the rumen.

The last critical area to consider is the fiber level to ensure a stable rumen environment for the microbes and maintaining proper pH and volatile fatty acid production. The only rule of thumb used in this study was to make sure that the goats were consuming over half their dry matter intake as forage. The forage needs to be palatable and something the goats will not be selectively consuming different from what the sample taken for the forage analysis. Having an intake record system in place is crucial for assessing diet fiber levels. It is not uncommon to find goat rations either balanced below 50% forage intake or rations that look to be balanced properly on paper but are being consumed differently, i.e. forage source not being consumed as believed.

Overall, the final ration goal was to balance forage intake to over 50% of intake. Concentrate feeding was then adjusted based on current stage of lactation that the overall herd was in. In general, most herds on this study fed on average 3 pounds of concentrate if the herd was in the early stages of lactation. Herds that were generally in the later days of lactation would reduce their overall concentrate feeding to below 3 pounds per day based on days in milk production and general condition score. These recommendations are based on the goat's needs in the first

60 days of lactation.

Table 4: Suggested Nutrient Recommendation Levels for Lactating Dairy Goats

Nutrients	Suggested levels
Crude Protein	**15 - 16%**
Undegradable Protein	**4 – 6%**
Starch	**15 - 20%**
Sugar	**4 – 6%**
ADF	**20 - 25%**
NDF	**32 - 40%**
Fat	**3 - 5%**
Calcium	**.7 - .8%**
Phosphorous	**.3 - .4%**
Magnesium	**.1 - .2%**
Selenium ppm	**0.30**
Vitamin E IU/lb	**9 IU/lb or 30 ppm**

Using these guidelines for developing rations for the lactating dairy goats, we found that the lack of relationship between grain fed (and % crude protein in the grain) and milk yield were reversed from year 1 of this study when ration advice was lacking and we used another system. This now positive relationship is demonstrated visually in while Table 5 lists the correlation coefficients at the P<.01 and .05 levels. There we see that MUN, body weight, body condition score are not strong indicators of milk yield in dairy goats. As well, level of concentrate supplementation was not correlated with MUN levels. So, while it is interesting to know the MUN, it is not essential for assessing the protein intake of dairy goats and confirms published data. It is thought that the high level of goat selectivity in their daily intake cause their MUNs to fluctuate widely. On average, goats in this part of the study were fed 1.6 kg (3.5 lbs) of concentrate and 240 gms(.53lbs)/day of protein from concentrate and all received between .2-.9kg (.44-2lbs) of dry hay.

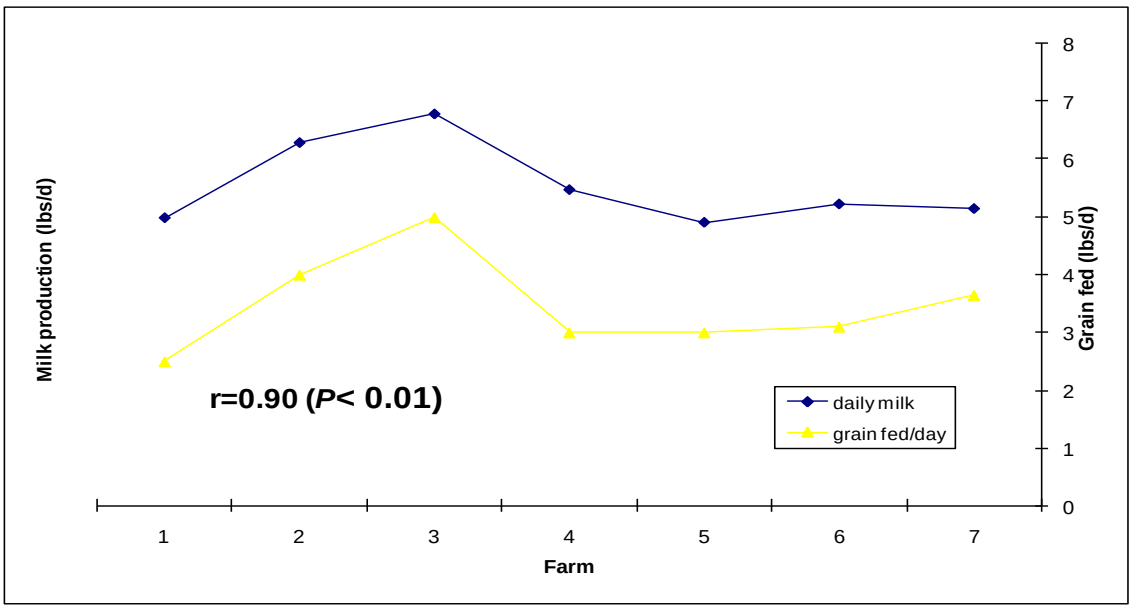

Figure 1: Relationship between average milk production (lbs) and grain fed per day (lbs) in final year of study.

Table 5. Relationships between all farm variables measured

	Milk yield (g/d)	Fat yield (g/d)	Protein yield (g/d)	CP of grain (%)	BW	BCS	Grain fed (g/d)	Grain cost ($/d)	Protein fed (g/d)	MUN
Milk yield (g/d)	-	0.82*	0.88**	-0.20	0.08	0	0.89**	0.79*	0.77*	-0.50
Fat yield (g/d)	0.82*	-	0.91**	-0.08	0.25	0.10	0.64	0.60	0.59	-0.38
Protein yield (g/d)	0.88**	0.91**	-	0	0	0	0.84*	0.79*	0.78*	-0.40
CP of grain (%)	-0.20	-0.08	0	-	0.39	0.80*	0	0.19	0.36	0.6
BW	0.08	0.25	0	0.39	-	0.79*	-0.11	-0.11	0	-0.17
BCS	0	0.1	0	0.80*	0.79*	-	0	0.10	0.25	0.31
Grain fed (g/d)	0.89**	0.64	0.84*	0	-0.11	0	-	0.81*	0.90**	-0.30
Grain cost ($/d)	0.79*	0.6	0.79*	0.19	-0.11	0.10	0.81*	-	0.85**	0
Protein fed (g/d)	0.77*	0.59	0.78*	0.36	0	0.25	0.90**	0.85**	-	0
MUN	-0.50	-0.38	-0.40	0.6	-0.17	0.31	-0.30	0	0	-

Data are Pearson correlation coefficient; ** = $P < 0.01$; * = $P < 0.05$

In 2007, 6 of the dairies fed their goats by pasture or browse during the growing season. Figure 2 presents their combined average monthly milk yield with fat% and protein % over the length of the lactation. On pasture-based farms, the average lactation length was 9 ± 1 months. The total average milk production over the entire lactation was 750 kg per goat. The average

cost of grain to support the production of 1 kg of milk was $0.22 ± 0.03 USD ($0.10±0.01 per lb of milk) .

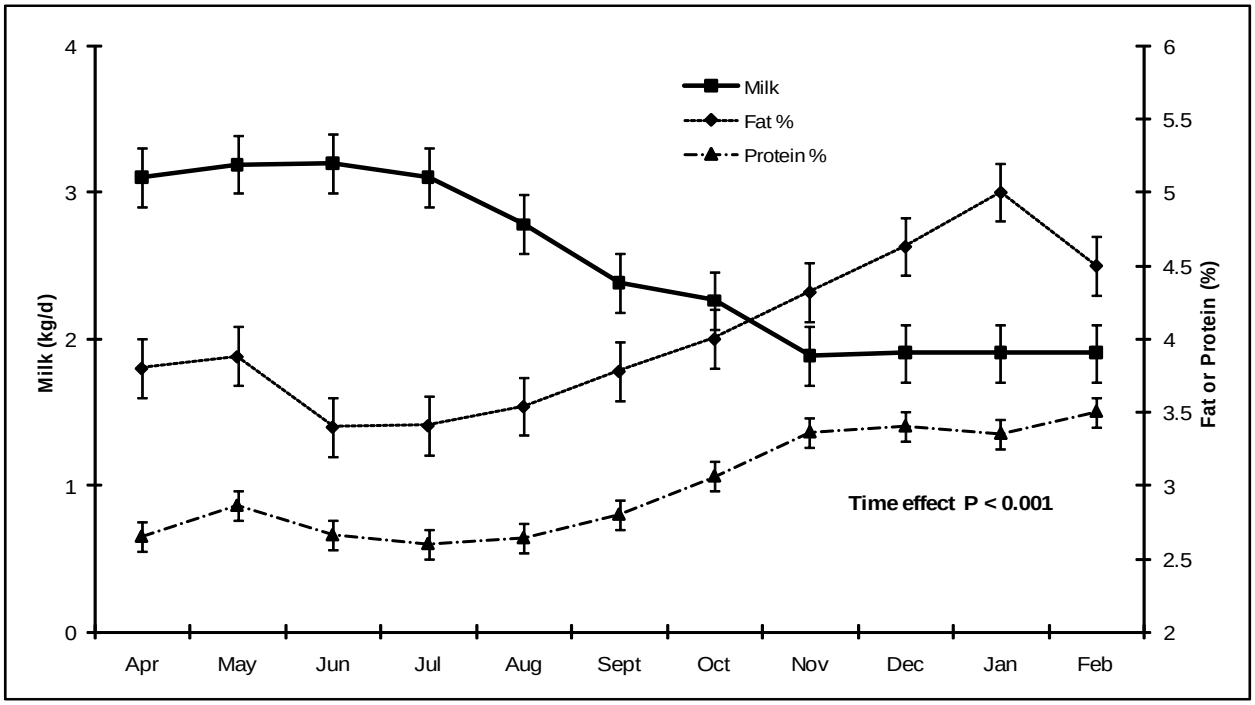

Figure 2: Average daily milk production, fat and protein % for 6 pasture based goat dairies in 2007

Impact of Results/Outcomes

After the project ended, 6 commercial goat dairies continue to work with a nutritionist at a feed company to balance their feed rations and one continues to use monthly milk recording with VTDHIA. Thus, farmers are better able to provide nutritionists with production information they need and one feed company is applying the information summarized in this project. We have a guideline with recommended nutrient levels for dairy goats that we believe worthy of testing and consideration on commercial dairy goat farms.

Economic Analysis

While unable to calculate financial savings from increased milk production or lowered feed costs (feed changes were made when the milk production was not necessarily metered by an impartial party and feed prices continue to rise monthly) we were able to calculate the cost of grain per unit of milk produced by the goats during their lactation from the data from 7 farms that pastured their goats over the time period in 2007, the last year of the project. The average cost of grain to support the production of 1 kg of milk was $0.22+/- 0.03 USD. This translates to $0.10 +/- 0.01 USD per pound of goat milk.

Publications/Outreach

In the fall of 2004, two workshops on dairy goat nutrition were offered to farmers and feed company representatives at the beginning of the study by Dr. Joanne Knapp, a ruminant nutritionist at the University of Vermont. She developed a handout explaining the protein and energy calculations needed to balance a ration and started use the LUGNC as the software program. Knapp started as co-PI of this project but left the employ of the University after only a few months into the project. In the fall of 2006, Dr. Antonello Cannas (formally of Cornell University and currently with the University of Sassari, Sassari, Sardinia, Italy), gave two workshops on dairy goat nutrition to farmers and feed company nutritionists. He left a PowerPoint presentation to share with others. He is one of the creators of the Small Ruminant Nutrient System software program created with 2 other researchers using models based on data from research around the world. A dairy goat nutrition article and handout were developed by the PI and presented in NY State in September 2006 and 2008. A poster and handout summarizing some of the project's last year of data was presented at the September 2008 International Goat Conference in Querétaro, Mexico.

International Goat Association, Queretaro, Mexico, 2008 Poster and Handout, Carol Delaney

Workshops in Vermont with Joanne Knapp and Antonello Cannas

Energy and Protein balancing handout by Dr. Joanne Knapp (pdf format only)

Balancing Diets for Lactating Goats, presentation by Dr. Antonello Cannas (ppt format converted to pdf)

Workshops in NY State: Caprine Outing September 2008, Carol Delaney

"Field Approach to Balancing Dairy Goat Rations", unpublished MSWORD, December 2008, Kevin Kouri.

Small Ruminant Dairy Newsletter Summer 2007 article "Resources for Balancing Rations" Carol Delaney. MSWORD

Chapter in "Guide to Starting a Commercial Goat Dairy Farm" (draft, Carol Delaney)

Farmer Adoption

One farm has continued using the milk production services of VT DHIA after this project ended as a management tool and to assist in ration balancing. This farm saw a 10-20% increase in milk production in the years during the study and they continue to work with their grain company for ration balancing. Another farm continues to work with their feed company nutritionist and saw a more than 30% rise in production with the same amount of input of grain over the course of 3 years. Three other farms continue to work with their feed company nutritionist after this project ended. One farmer is 'married' to purchasing bagged grain and was unable to switch to recommended rations because they come in bulk form and he does not own a bulk bin. He

hesitates to go to bulk grain because his goats have refused to eat new formulations before and his milk production plummets. Due to distance from her organic feed company, one farmer found it easier to deal directly with them to expedite deliveries instead of going through a consulting nutritionist from another feed company. This created another step that interfered with timely delivery of grain.

In the end, 6 farms continue to work with a feed company representative to balance their rations and one continues to use monthly milk recording with VTDHIA.

Areas Needing Additional Study

It would be interesting to focus on a small number of commercial dairy goat farms and keep daily production records (the farmer or a technician could calculate that) so that application of these suggested feeding recommendations for rations could be evaluated as soon as diet changes were implemented. Afterwards, using the data, the current software programs could be compared in how well they predicted the outcome. These programs include the Small Ruminant Nutrition System, UC Davis CAPRICORN WIN08 (both available for purchase) and Langston University's Goat Nutrient Calculator (free online program).

APPENDICES

Changes in Plan of Work

In the first two years of data collection, technicians were hired and trained to use meters to measure milk production, take milk samples and they were also trained to weigh and body score the goats. In the third year, the Vermont Dairy Herd Improvement Association (VT DHIA) was contracted with to provide the milk measurements and analysis and the software to keep track of

that information ways more cost effective. Since the herd sizes were lower than expected, the budget was able to cover this added expense of the software service which proved to be invaluable. For on-farm work on multiples of farms, contracting data collection with an existing service with built in support for their employees and equipment makes the most sense. For future grants, with limited funds, the best information would be provided by using an expert service, like VT DHIA, and choosing to work with less farms.

Another change was unexpected and diminished the projected impact of the study. After working as the nutritionist for the study for a few months, the first nutritionist collaborator left the employ of the University of Vermont in December 2004 and did not continue on the grant. The farms were kept on the data collection study (January 2005-October 2005)to keep the momentum going and finding another nutritionist proved difficult yet one agreed in June 2005 to start balancing rations. This nutritionist was not able to follow through with any ration balancing and the study was put on hold after October 2005. Thus, little impact was demonstrated on the farms.

The grant began again in early 2007 with the assistance of new ruminant nutritionist faculty member at the University of Vermont. Dr. Matthew Waldron. Unfortunately, this person also left the employ of the University and was unable to provide the volume of input desired. Luckily, one of the farmers on the study approached a feed company representative/feed nutritionist after hearing him speak at the Vermont Grazing Conference in 2006 and enticed him to work with them. This nutritionist became the new collaborator and created new rations for the farms on the study from spring 2007 through spring 2008. We started collecting milk measurements using VT DHIA in the spring of 2007 and ended all but one farm by February 2008.

Resources

See files on provided CD marked:

"Knapp60001" for handout produced by Dr. Joanne Knapp entitled: "Formulating and Evaluating Rations based on Metabolizable Energy and Metabolizable Protein Requirements for Lactating Goats (Imperial Version)"

"LNE04-200 Field Approach to Balancing Dairy Goat Rations" by Kevin Kouri, M.S.

"PosterLNE04-200" for Poster presented at the International Goat Conference in Quarétaro, Mexico, September 2008 of data summarized for last year of project. Title: Effects of concentrate supplementation on milk yield and MUN concentration on commercial dairy goat farms"

"LNE04-200Posternotes" for additional data and information on project results to accompany poster (above).

"LNE04-200pptBalancingDietsforLactatingGoats2006" contains a presentation provided by Dr. Antonello Cannas, small ruminant nutritionist from the University of Sassari, Sassari, Sardinia, Italy.

Publicity

In 2004, we published an article at the start of the project to announce the project to the agricultural community. The article was called "*New SARE grant aims to feed goats well*" and appeared in the UVM Center for Sustainable Agriculture's newsletter, *Cultivating Connections*, in the Volume x, Number 3, Summer 2004 issue. (See http://www.uvm.edu/sustainableagriculture/Documents/Summer04-3.pdf) It was also published in the Vermont Agency of Agriculture, Food and Markets' newsletter, *Agriview*, in the Summer of 2004. See file marked "LNE04-200NewNESAREgrantpr04"

Economic Data

While unable to calculate financial savings from increased milk production or lowered feed costs (feed changes were made when the milk production was not necessarily metered at the time of the ration change and feed prices continued to rise monthly) we were able to calculate the cost of grain per unit of milk produced by the goats during their lactation from the data from 7 farms that pastured their goats over the time period in 2007, the last year of the project. The average cost of grain to support the production of 1 kg of milk was $0.22+/- 0.03 USD. This translates to $0.10 +/- 0.01 USD per pound of goat milk.

The service of measuring milk production and milk components for individual goats makes a large contribution to the farmer's information bank which she draws upon to select the best animals for future years. Thus, providing this service allows farmers to improve their production and was a big reason farmers signed up for the study. Two farmers saw between 10-30% increase of milk production in their herds over 2-3 years while using this collected data as well as some ration balancing provided by this project.

Primary Audience

Deb Hogan, 2191 Leicester-Whiting Rd., Whiting, VT 05775, 802-247-3363, EIEIOFRM@aol.com

Sharon Kerwin, 2141 West Street, Cornwall, VT 05753, 802-462-3486, sekerwin@hotmail.com

Laini Fondiller, Lazy Lady Farm, 973 Snyder Brook Road Westfield, VT 802-744-6365, laini@sover.net

Norman McAllister, Norms Kids, 712 Hanna Road, Franklin, VT 05457, 802-285-6363

Kristan Doolan and George Van Vlaanderen, Does Leap Farm, 1703 Rte 108 S.East Fairfield, VT 05448, 802-827-3046, doesleap@verizon.net

Jonathon Manns, Shady Maples Farm, 1141 Delorm Road, Leicester, VT 05766. 802-247-3362, goat1141@comcast.net

Chris Lekberg, Brownell Pond Farm, 802-247-5706, 1155 Richmond Road, Brandon, VT 05733, 802-247-5706, BYEPOND@aol.com

Theresa and Tom Hack, 1670 High Pond Road, Brandon, VT 05733, 802-247-6101

Hannah Sessions and Gregory Bernhardt, Blue Ledge Farm, 2001 Old Jerusalem Road, Salisbury, VT 05769, 802-247-0095, blueledge@hotmail.com

Lynn and Martha Rockwell, Long Field Farm, PO Box 64, Houston Hill Road, Cabot, VT 05647, 802-563-2999, juneiris@sover.net

Theresa and Lee Lawyer, 2849 Witch Cat Road, Enosburg Falls, VT 05450, 802-933-8871, lawyerlt@yahoo.com

Claude and Chantal Roberge, 415 Pine Street, North Troy, VT 05859, 802-988-4313, goat_farmer415@hotmail.com

Eric Lindstam and family, 145 Powder Spring Road, Groton, VT 05046, 802-588-2031, begone71@hotmail.com

Farmer Testimonials

Lynn Rockwell, Long Meadow Farm, Cabot, VT,(from Letter of Support, March 3, 2008-hand written). Lynn Rockwell has been on the SARE Goat Nutrition grant from the start in 2004. In looking at her milk production records between 2006 and 2007, she increased her milk production .5 lbs per day per goat over the lactation period. She is feeding less grain and making more milk per goat so she can milk the same or less goats.

"To Whom this May Concern:

We partook in the Goat Nutrition Project through UVM Small Ruminant Office. We found it valuable to have access to monthly DHI testing for the length of the project. We could not have justified this expense without the project but found this information very helpful when deciding

which animals are of superior quality. The long term quality of our herd was helped by this project. Regards, Hannah Sessions,Blue Ledge Farm, Leicester, VT"

"*I was a farmer participant in the SARE grant "Implementing Goat Nutrition Programs for Improvement of Farm Sustainability"* for the duration of the grant. This grant helped me in several ways. First and foremost, we were connected with a nutritionist who helped us formulate a ration based on our pasture and hay analysis. Prior to the grant we had been feeding a basic dairy ration, changing it slightly with the seasons to account for what we thought was going on. Our milk production improved substantially during this time and our problems with metabolic problems, most notably Milk Fever, were greatly diminished. We have continued to work with this nutritionist since the grant has finished and he has continued to help us with important decisions regarding our ration.

The DHIA services were also very helpful as they really helped us with our selection of young stock. The percent solids can vary widely from goat to goat and this makes a significant difference in our yield of cheese. Since a young goat is producing milk at about 14 months of age we have quickly seen an improvement in the quality of our first fresheners, probably due to a combination of better nutrition and better selection.

Our farm is a small farmstead cheese operation on 125 acres. Our income and financial sustainability has been improving over the last few years. In 2005 we milked 32 goats and grossed $50,000 in dairy products, or $1,560 per milking goat. In 2007 we grossed $82,000 with 44 goats for an average of $1860 per goat. 2008 is already over $100K in sales with 45 goats for an average gross per animal of over $2200. A part of this success was due to our greatly

improved nutrition and selection process. We have also been able to eliminate off farm income during this time period. Thank you, *Kristan (Doolan), Does' Leap Farm, East Fairfield VT"*

Final Financial Report

The final financial report is on file at NESARE. $122,549.96 of $135,246 award was spent.

Slides/Photos

See file marked "Photo" in CD provided.