

**PROCEEDINGS OF THE  
8<sup>TH</sup> GREAT LAKES  
DAIRY SHEEP SYMPOSIUM**

**November 7-9, 2002**

**CORNELL UNIVERSITY  
ITHACA, NEW YORK**

**Organized By:**

Cornell University

College of Agriculture and Life Sciences

Departments of Animal Science and Food Science

College of Veterinary Medicine

Dairy Sheep Association of North America

# **8<sup>TH</sup> GREAT LAKES DAIRY SHEEP SYMPOSIUM**

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East Friesian-cross and Lacaune-cross dairy sheep coming from pasture to the milking parlor. Most dairy sheep are raised on small family farms and receive most of their nutrition from natural pastures.

Photo by Maristela Rovai.

Dairy ewes being milked in a modern, hygienic parlor. Sheep milk is produced under strict sanitary controls and under the watchful eye of dedicated shepherds to ensure the highest quality.

Photo by Maristela Rovai.

Speciality cheeses in an up-scale food store in Manhattan, New York City. An increasing number of such cheeses are sheep milk cheeses produced in North America.

Photo by Dave Thomas.

*Copies of the 1995 through 1997 Proceedings of the 1<sup>st</sup> through 3<sup>rd</sup>, respectively, Great Lakes Dairy Sheep Symposia can be purchased from the Wisconsin Sheep Breeders Cooperative, 7811 Consolidated School Road, Edgerton, WI 53534, USA (phone: 608-868-2505, web site: [www.wisbc.com](http://www.wisbc.com))*

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## PROGRAM

### 8<sup>TH</sup> GREAT LAKES DAIRY SHEEP SYMPOSIUM

CORNELL UNIVERSITY  
ITHACA, NEW YORK

Thursday, Friday, and Saturday  
November 7, 8, and 9, 2002

#### Thursday, November 7

##### *Livestock pavilion*

All day Sponsor displays—visit the displays of symposium sponsors of feed, equipment, and supplies.

##### 9:00 **Registration**

Presymposium program - “Introduction to Dairy Sheep Farming”

- Getting started - Bee Tolman
- Management - Ken Kleinpeter
- Marketing farmstead cheeses - David Major
- Marketing lambs and cull ewes - Mike Thonney

12:00 Lunch and introductions

##### *146 Morrison Hall*

1:00 **Welcome** – Alan Bell, Chair, Department of Animal Science

##### 1:10 **Invited speaker:**

Nutritional strategies to improve lactation persistency in dairy ewes - Antonello Cannas

2:10 Collecting and managing data effectively: A case study from the Comisana breed -  
Francesco Pinelli

3:00 Question and answers

3:10 Break with cheeses from our sheep dairies

3:35 Nutrition and management of dairy sheep on pasture - Bruce Clement

4:05 Questions and answers

4:15 Charter meeting of the Dairy Sheep Association of North America (DSANA) with  
election of officers

##### *Livestock pavilion*

6:00 Lamb dinner and opportunity to meet your fellow dairy shepherds

## **Friday, November 8**

### *Boyce Thompson Institute Auditorium*

- 8:00 Flock health management - Dr. Mary Smith and Dr. Sue Stehman
- 9:45 Questions and answers
- 9:55 Break with cheeses from our sheep dairies
- 10:30 Lamb pneumonia vaccination trials - Dave Thomas and Mike Thonney
- 11:15 A breeding program for dairy sheep: Why and how? - Pascal A. (Toni) Oltenacu
- 11:50 Questions and answers
- 12:00 Tour of College of Veterinary Medicine

### *College of Veterinary Medicine Cafeteria*

- 1:00 Lunch (cost of lunch not included)

### *146 Morrison Hall*

- 1:45 Specialty cheeses - Cathy Strange
- 2:25 Milk composition and cheese yield - William Wendorff
- 3:05 Questions and answers
- 3:15 Break with cheeses from our sheep dairies
- 3:30 Economics of winter milking for medium to large dairy sheep operations - Yves Berger
- 4:00 Start-up and operating costs of small farmstead cheese operations - Carol Delaney
- 4:30 Questions and answers
- 4:40 Tour of Food Science pilot plant including 1) cheese evaluation, 2) new topics in dairy processing, & 3) sheep milk ice cream production - Dave Brown, Dave Barbano, and Brandon Nelson

### *Trillium Dining Room, Kennedy Hall*

- 6:30 Cocktails and banquet
  - Welcome and introduction of speaker - Susan Nenry, CALS Dean
  - The future of specialty agriculture in New York - Nathan Rudgers, Commissioner of the New York State Department of Agriculture and Markets

## **Saturday, November 9**

### *146 Morrison Hall*

- 8:00 Somatic cell counts and mammary infections on small ruminant dairies in Vermont - Dan Scruton
- 8:45 DNA markers for aseasonality and milk production in sheep - Raluca Mateescu
- 9:30 Questions and answers
- 9:45 Pick up box lunches and leave for tour

### *Farm Tour*

- 10:30 Cornell Sheep Farm, Harford
- 12:00 Lunch at Teaching and Research Center Headquarters Building
- 12:45 Leave for Northland Sheep Dairy (Karl North), Marathon, NY
- 1:15 Tour of Northland Sheep Dairy (Karl North), Marathon, NY
- 2:15 Leave for Bee Tolman Farm, Cazenovia
- 3:00 Tour of Bee Tolman Farm
- 4:30 Begin return to Ithaca
- 5:45 Arrive in Ithaca

## SPEAKERS

**Dave Barbano**, Professor of Food Science, Cornell University.

**Alan Bell**, Chairman, Department of Animal Science, Cornell University.

**Yves Berger**, Shepherd and Superintendent, Spooner Agricultural Research Station, University of Wisconsin.

**Dave Brown**, Senior Extension Associate, Department of Food Science, Cornell University.

**Antonello Cannas**, Invited speaker sponsored by the Babcock Institute for International Dairy Research and Development. Associate Professor of Animal Science, Dipartimento di Scienze Zootecniche, Università degli Studi di Sassari, Italy.

**Bruce Clement**, Program Leader, Agricultural Resources, UNH Cooperative Extension, Durham, NH.

**Carol Delaney**, Small Ruminant Dairy Specialist, UVM Center for Sustainable Agriculture and UVM Department of Animal Science, Vermont.

**Susan Henry**, The Ronald P. Lynch Dean of Agriculture and Life Sciences, Cornell University.

**Ken Kleinpeter**, Farm Manager, Old Chatham Shepherding Company, Old Chatham, New York.

**David Major**, Owner and Operator of Major Farms, Vermont.

**Raluca Mateescu**, Graduate Assistant, Department of Animal Science, Cornell University.

**Brandon Nelson**, Lecturer, Department of Food Science, Cornell University.

**Karl North**, Owner and Operator, Northland Sheep Dairy, Marathon, NY.

**Toni Oltenacu**, Professor of Animal Science, Cornell University.

**Francesco Pinelli**, Leader, Comisana Breeding Program, Istituto Sperimentale Zootecnico per la Sicilia, Palermo, Italy.

**Nathan Rudgers**, Commissioner of the New York State Department of Agriculture and Markets, Albany.

**Dan Scruton**, Dairy Systems Coordinator, Vermont Department of Agriculture, Food and Markets, Montpelier.

**Mary Smith**, Associate Professor of Population Medicine and Diagnostic Sciences, Cornell University.

**Sue Stehman**, Senior Extension Veterinarian, Population Medicine and Diagnostic Sciences, Cornell University.

**Cathy Strange**, National Cheese Buyer, Whole Foods Market.

**Dave Thomas**, Professor of Animal Science, University of Wisconsin-Madison.

**Mike Thonney**, Professor of Animal Science, Cornell University.

**Bee Tolman**, Dairy Sheep Farmer, Cazenovia, New York.

**William Wendorff**, Professor and Chair, Department of Food Science, University of Wisconsin-Madison.

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## INTRODUCTION TO DAIRY SHEEP FARMING — GETTING STARTED

**Bee Tolman**

**Tolman Sheep Dairy Farm  
Bee Tolman & Simon Hurley, owners  
Bee Tolman, operator  
Cazenovia, New York**

This was our 4<sup>th</sup> year in operation, and our 3<sup>rd</sup> year milking. We have 230 ewes all up, and produced a total of 47,000 lb of milk this year. We do not own the farm, nor do we own any machinery. We rent the farm and include a pasture-maintenance fee in the rent. We purchase all our feed, both hay and grain.

Due to very limited barn space, production is seasonal: our top 60 ewes will lamb out in late February, the remaining 170 will lamb out on pasture in late April/ early May. We wean our lambs at 30 days and start milking at that point. Our ewes are milked in a 12-bail rapid-exit parlor; the milk is bagged in 8-gallon bags and shipped frozen to the buyer. The milking ewes are metered in the parlor every 2 to 3 weeks. Our immediate goal is to average 400 lb milk (after weaning) per ewe per year. We sell all our milk to a processor, and do no value-adding of the milk ourselves.

Perhaps the best way to couch any thoughts I have on getting started in sheep dairying is to show our projected income statement for the year 2005, when we hope to achieve our 400-lb goal.

<b>Projected income statement, 2005</b>			
<b>Revenues</b>	Milk revenues (net of packing and shipping costs)	220 ewes * 400 lb * \$0.66/lb	\$58,000
	Lamb sales	360 lambs * \$70/hd	\$25,200
	Other revenues (wool, culls, side jobs, USDA)		\$4,000
<b>Total revenues</b>			<b>\$87,200</b>
<b>Expenses</b>	Livestock (feed, vet, shear, rams, dogs, transport)		\$22,100
	Property (rent, pasture, dairy suppl, R&M, electricity)		\$18,800
	Admin (insur, prof fees, phone, side job exp)		\$5,900
	Hired labor		\$21,000
	Depreciation		\$13,000
	Interest on loans		\$1,200
<b>Total expenses</b>			<b>\$82,000</b>
<b>Net farm income (return to operator labor &amp; equity capital)</b>			<b>\$5,200</b>

**Getting started.** I am addressing this presentation to those who are thinking of starting a viable, profitable sheep dairy business, where the primary focus of the business is milking sheep and marketing sheep milk.

- I. No business plan, no business
- II. Time
- III. Control your overhead
- IV. Invest in milk-recorded stock
- V. The devil in the details
- VI. That off-farm job
- VII. Plan to value-add your milk
- VIII. Talk, research, visit, talk

### **I. No business plan, no business**

- Do a complete business plan before you do anything else. Include all financial statements in detail. Don't miss the details — they will be your undoing (see “the devil in the details” below). And be conservative. I was advised by a goat dairy farmer (who has since folded) to add 30% to all budgeted costs. I didn't. I now know that if I had, my plan would have been far more accurate.
- Plan to maintain ongoing financial statements. With seasonal sheep dairying, 2/3 of your expenses will be in the first six months of the year, while 3/4 of your revenues will be in the second six months of the year. A rolling cash flow will help you manage those winter/spring shortfalls. Your multi-year projected income statements will tell you whether your farm business is healthy or if you need to make some serious changes.
- Be prepared to figure your cost of production. This will help you determine breakeven points for milking individual ewes and for milking your whole flock. You will find that time is precious and expensive, and milking breakeven (or below breakeven!) animals is just a waste of time.

### **II. Time**

For me, time has been the killer. I had originally thought I could operate the farm alone, with very limited part-time help. I was wrong. From March to November, this farm is a two-person operation. My husband works off-farm, so I have had to hire someone full-time to help me on the farm. I am thus paying someone else what I had originally thought I would be paying myself.

If you think you can run a sheep dairy single-handedly, consider this average day during milking season:

- Milking time 3-1/2 to 4 hrs/day (1-3/4 to 2 hrs/milking)
- Cleaning parlour/milkroom/yard..... 1 hr/d (1/2 hr/milking)
- Getting sheep to/from parlour ..... 3/4 hr/d
- Moving fence for milkers ..... 1/2 hr/d
- Bagging milk for freezer ..... 1 hr/d (incl. cleaning bulk tank)

That's 7 hours a day, 7 days a week. And you still haven't fed any lambs, dewormed or vaccinated any lambs, rotary mowed to keep your pasture quality high, made hay (if you feel compelled to do such a thing), marketed any lambs, metered milk, entered records, done your farm accounts, or any other of the myriad things associated with a farm of 200 ewes and 400 lambs. Not to mention that fact that you have also not eaten lunch or dinner, seen any friends, or conversed with your spouse.

### **III. Control your overhead**

Overhead costs you in two crucial places: first it competes for limited cash when you're starting up, and then, as interest cost, it continues to compete for limited operating cash.

Regarding finding a suitable farm location, I'll repeat the advice of Jon Tappe, a Wisconsin producer:

- Look for buildings that can be modified or renovated, where someone else has paid the depreciation
- Consider renting. In Wisconsin (as in Upstate New York), there are plenty of quality farms available for rent. Although you don't need expensive equipment for handling or housing the sheep (used and home-made are more than adequate and will save heaps of money), I personally think that quality pays when it comes to the milk equipment, i.e., milking system, bulk tank, freezer.
- A good, labor-efficient milking system will save you time (that's \$\$).
- I skimmed on the bulk tank, and had to dump 75 gallons when it failed (\$\$), and then had to pay for repair and new refrigerant (more \$\$).
- I have seen used freezers in place that run very inefficiently or leak warm air through gaps (that costs electricity = serious \$\$). (And actually, if you can find a market that does not require you to freeze your milk, dance a jig. The freezer is an enormous expense to purchase and to operate.)

### **IV. Invest in milk-recorded stock**

I started with non-dairy ewes (130 Finn-Dorsets) and crossed them with East Friesian rams. I did this because of the high cost of crossbred East Friesian stock at the time (5 years ago). In retrospect, I wish I had done it differently. I wasn't prepared for the amount of genetic variation and the consequent variation in production (i.e., half-breds that look like Friesians but milk like Finns).

So, from the school of hard knocks:

- Only buy breeding stock from flocks with milk production records. Lamb growth rates tell you *nothing* about an ewe's potential as a dairy producer. Invest in good-quality stock — they will pay for themselves. Again, just because an animal is East Friesian does not mean it will be a profitable dairy producer. Get good animals from a flock that meters regularly.
- Plan for a greater than 20% cull rate. The East Friesian gene pool in America is not like the Holstein-Friesian gene pool in America, in that the East Friesians have not gone through decades of intensive breeding and selection. Most dairy animals available for sale are crosses from flocks with very limited production histories. You will therefore find huge variations in production, udder conformation, disease susceptibility, and milking attitude.

To give you an example, in 2001 we bred 87 ewe lambs, who averaged 63% East Friesian as a group. By June 2002 we had culled:

- 3 for being empty
- 2 for small teat openings
- 2 for terrible, incorrigible attitudes in the parlour
- 2 for mastitis
- 7 for insufficient production in the parlour

## **V. The devil in the details**

When putting together your business plan, get down to the level of detail. Ignored “little details” will come back to haunt you later. Here are a couple of examples of operating expenses that I guesstimated on in my original plan (and was way off the mark):

- Electricity. From January 1 to September 30 of this year, electricity at the barn was \$2,800 (I had originally guesstimated \$1,000 per year, ha ha). We expect it to rise another \$600-\$800 next year as we extend our milking season and increase production. At peak this year, electricity cost us \$15.56 per day; the freezer alone accounted for \$10.08 of that daily cost.
- Shipping milk. To be honest, in 1998 I hadn’t quite envisioned how the milk was physically going to get from point A (bulk tank) to point B (processor). One small part of it turned out to be the bags that milk is poured into (this year, 1189 bags at \$0.55 each = \$654) and the boxes the bags are packed in (34 boxes at \$12 each = \$408).

These are only a couple of small operating expenses. Details, really. I hadn’t planned for them, and together they account for \$5,000 in annual operating expenses.

## **VI. That off-farm job**

At this point, for 95% of us, sheep dairying will not support a family. You need to plan on a family member holding an off-farm job for cash flow, health insurance, and savings.

## **VII. Plan to value-add your milk**

Although that \$5,000 net farm income shown on the first page of this presentation is technically “profit”, our sheep dairy operation certainly does not provide an adequate return to labor or investment. It is my firm belief that, given the price of sheep milk, *an operation that milks sheep and simply sells the milk will not be viable.*

Value-adding is admittedly easier said than done — it is yet another level of capital investment, time investment, and risk. But *at this point I would not contemplate starting a sheep dairy operation without including some plan to capture a portion of the value-adding process.* As Wisconsin producer Tom Kieffer put it: “The farther you can integrate vertically into the market — from the lowest point (like us, selling milk) toward the ultimate consumer — the better off your business will be.”

## **VIII. Talk, research, visit, talk**

- Go visit people who are milking sheep (and, if possible, value-adding)
- Check your budget amounts with people who have already invested/built/installed
- Get the pros and cons of various options (for instance, breeding stock source farms, milking systems) before you buy.

Good luck.

# BEGINNING MANAGEMENT FOR A SHEEP DAIRY

**Ken Kleinpeter**

**Old Chatham Shepherding Company  
Old Chatham, New York**

What I intend to do in this presentation is give a brief overview of basic management options and decisions new sheep dairy producers will have to consider in setting up their operations. What any individual producer will decide to do will depend on a large variety of factors, including financial resources, husbandry experience, existing facilities and lifestyle considerations, to name a few.

## **What type of sheep to milk?**

### **1. Starting with an existing flock:**

I personally believe it is difficult to impossible to have a viable sheep dairy farm without dairy type sheep. In a dairy sheep operation, income from milk sold has to exceed the greater costs of running a sheep dairy operation. While there are certainly individual exceptions in any sheep breed, on average only dairy sheep and their crosses will produce an adequate amount of milk to meet this requirement.

In North America, with the exception of a few Lacaune, the only true dairy sheep we have available is the East Friesian. Most of you probably know that the East Friesian is considered the most productive dairy sheep in the world.

That being said, it would be very expensive to start an operation with all purebred or even crossbred dairy sheep. On an established sheep farm, you already have sheep and the facilities to manage them, so I believe the best approach would be to buy the best quality East Friesian rams you can find and afford and spend a year or two creating your own crossbred flock. In addition to being the least expensive way to build a sheep dairy flock, this approach also takes advantage of built-in flock immunity to pathogens that are specific to your operation.

The East Friesian is a prolific lambing breed, averaging about a 230 percent lamb drop. So even if you never end up milking sheep, the East Friesian crossbred ewes you produce will be very good commercial lamb producers, having a high percentage lamb drop and plenty of milk to raise those twins and triplets.

### **2. Starting a flock from scratch:**

My advice for starting a dairy sheep flock from scratch isn't much different. I would recommend buying the best quality commercial type ewes you can find, and then buying East Friesian rams to breed to those ewes. Good quality commercial ewe lambs should be available for \$100 or less, depending on the source and the quantity you buy, while East Friesian crossbred ewes, if you could find them, would run a minimum of between \$350 to \$400 each. Again, plan on at least a year of breeding-up to produce your dairy sheep flock.

## **Milk Seasonally or Year Round?**

### **1. Seasonally:**

Because of the strong seasonal breeding characteristics of dairy sheep breeds, most dairy sheep farms worldwide milk only seasonally. There are obvious advantages to this approach, not the least being that you get some time off each year from the milking routine. You are also working with the nature of the sheep, and especially if you will be a pasture-based operation, you can plan your lambing to take advantage of the best quality grass. Also, if you are not milking in the Fall and Winter, your stored feed will not have to be as high quality as it would if you were feeding lactating ewes.

The disadvantage of seasonal milking is that your labor and facilities will be over-taxed at certain times of the year, and under utilized at other times.

### **2. Year Round:**

The biggest possible advantage to year round milking may depend on your market. If you are selling your milk to established cheese makers, odds are their operations will need milk all year. If you are near enough to your buyer to be able to deliver fresh milk in the Fall and Early Winter months, you will almost certainly receive a premium price for that milk. Of course, if you plan to make your own cheese and want to be in the market with your product all year, you will also be forced to milk all year.

Other advantages are that the demands on your labor and facilities will be more evenly distributed throughout the year, and that you will have a more consistent revenue stream throughout the year.

The obvious first disadvantage to milking all year is that there is never a break from the milking routine. Also, year round milking means that at least a portion of your flock will have to lamb “out of season” so that you will have lactating ewes all year. While this can be accomplished using light control protocols, there are costs associated with setting up facilities for light control, and because light control protocols are not 100 per cent effective, there will inevitably be ewes that will miss a year of production.

Also, the quality of your stored feed will have to be much higher to feed lactating ewes through the Fall and early Winter.

## **Feeding Options:**

### **1. Pasture:**

Well-managed pasture with simple supplementation is an excellent way to feed even high producing dairy sheep. The key phrase here is “well-managed.” It is beyond the scope of this presentation to discuss everything that goes into producing high quality pasture, but suffice to say there is quite a learning curve associated with becoming a skilled “grass farmer.” There are many publications and seminars devoted to grazing management.

The advantages of a well managed grazing operation are many, including less labor, cheaper feed costs, healthier animals and healthier milk. There will also be much less manure accumulation in the barn, which will save the labor and expense of frequent barn cleaning.

However grazing is a more “knowledge intensive” approach that might not be appropriate for the beginning farmer. New farmers must carefully consider paddock design, and fencing costs in setting up a pasture based system. Grazing is also much more dependent on weather than some other systems, and parasite control becomes a concern, because many wormers are not approved for lactating ewes. The quality of the pastures will always vary with the seasons, which can affect milk quantity and quality.

Finally, if you are endeavoring to have a year round lambing flock using light control, ewes that are on pasture at night will not be eligible for that protocol.

## 2. Confinement Feeding:

In this system the milking flock is confined in a barn or dry lot/barn and feed is brought to them. This feed can be as simple as free choice hay in the barn and a grain supplement in the parlor, as sophisticated as a balanced TMR or Total Mixed Ration, or somewhere in between. Again, it is beyond the scope of this presentation to go into a discussion of balancing rations for dairy sheep. Rather I want to simply point out different feeding options and the advantages and disadvantages of each.

The advantage of confinement feeding, other than being simple for beginners, is control. Control of the animals, and control of the quality of the rations. The milking flock can stay under lights during part of the night, which can increase lactation length and encourage out of season breeding for producers who wish to milk all year.

The largest disadvantage is greater feed costs, either through buying forage from off the farm or through harvesting on farm forage and transporting it to the sheep. Also the barn and/or dry lot will have to be cleaned more frequently.

## **How to Manage Lambs:**

One of the biggest decisions facing the dairy sheep producer is how the lambs will be raised.

1. Raise all lambs artificially from two to three days old.
2. Let ewes raise lambs for 30 to 40 days, then start milking
3. Milk ewes with lambs once a day for 30 to 40 days
4. Sell baby lambs at two to three days old.

Each system has advantages and disadvantages, and which is the best for any given operation depends on a number of factors. In our operation, in any given year we will use all of the above options.

System One and System Four are most appropriate if you want to maximize milk production. These systems will be most profitable if you are receiving a high price for your milk, and especially if you are selling your milk as finished products. I figure the average ewe will produce about 90 to 120 pounds of milk in the first 30 days of her lactation. At a price of \$0.65 per pound, this milk would be worth between \$58.00 and \$78.00. Of course the loss would be greater for higher producing ewes.

System One will only be profitable if you have a premium market for hot house lambs, and you have the specialized facilities and excess labor required to artificially raise a large number of lambs. I think it costs about \$50.00 in direct cost to raise a lamb from three days old to hot house lamb weight. In most markets a 40-pound hot house lamb will bring between \$55.00 and \$65.00. At those prices this enterprise is marginal at best. However, if you can average \$70 to \$75 per lamb, it might pay.

On the other hand, if you can find someone who specializes in raising baby lambs in your area, you could sell your three-day-old lambs for between \$8.00 and \$12.00. This is only slightly less than you would make by raising the lambs to 40 pounds, and you won't incur the inevitable death loss associated with raising a large number of lambs artificially. Of course in this system you would still have to artificially raise your replacement lambs, but replacement lambs are much more valuable than hot house lambs, so the payback is better.

The least labor option is to allow the moms to raise their lambs for 30 to 40 days, wean the lambs and then start milking. However, in this system you will lose the \$58.00 to \$78.00 worth of milk from the first 30 to 40 days, and the lactations of some ewes will be shorter as a result of this system, which means you would ultimately lose more money on milk lost.

I believe that for most farms, the once a day system is the optimal one. In this system the lambs spend the days with their mothers, and are separated at night. The ewes are milked only in the morning. The lambs are then weaned at 30 to 40 days old, and the ewes are then moved to the twice a day system.

Although this system has a few drawbacks, which I'll explain in a moment, this is the most profitable approach if you are selling milk and not finished products. A study at the University of Wisconsin a few years ago, concluded that ewes that are milked once a day for 30 days while raising their lambs, produce only about 66 pounds less milk in that time than they would if they were milked twice a day. This is primarily because the additional stimulation of the nursing lambs causes the ewes to produce more in the morning milkings than they would if the lambs were not nursing during the day.

At a price of 65 cents a pound, the milk lost amounts to about \$43.00. Remember that it cost at least \$50.00 each to raise a lamb to weaning artificially. So if your once a day ewe is raising a single, you are about seven dollars ahead of the game, however, if she is raising twins, you are \$57.00 ahead.

Other than the minimal labor required to separate the lambs each day, the major disadvantage of the once a day system is a somewhat lower fat percentage in the milk from the once a day ewes. This reduction in fat is only temporary, however. When the lambs are weaned and the ewes are started on a twice a day milking schedule, the fat in their milk quickly rises to normal for the flock.

The reduced level of fat in the milk from the once a day ewes could be a problem if all of your ewes are on a once a day schedule at the beginning of a milking season. However, if some of the milking flock is also on a twice a day schedule, the mixed milk will usually be in the acceptable range

The other disadvantage we have found is a slightly higher percentage of mastitis in the once a day ewe group. This is probably because well maintained milking machines are actually gentler on the udders than the lambs.

### **What to do with the milk:**

Unfortunately, there is not yet an established infrastructure in the United States for sheep milk like there is for cow milk. If you milk cows anywhere in this country, the milk truck will come and take it away. You may not like the price you get, but at least you can sell it. This is not the case with sheep milk. As a producer of sheep milk, you must arrange to find a market for either the fluid milk or the finished products.

There are basically three options, depending on how much milk you plan to produce, where you are located, and what skills you possess, or are willing to acquire.

The first and simplest option for beginning operations is to find an established cheese or yogurt maker who would like to buy your milk. You may be lucky enough to have a sheep cheese processor near you. If so, they may want to buy your milk.

If there are no sheep cheese processors near you, look for small or medium sized cow or goat milk processors who may want to buy your milk so they can add a line of sheep milk products to their established products. Forget about larger cheese plants, their equipment is sized for batches that are far larger than the amounts of milk you will be able to supply. Goat cheese producers are usually a good fit. They have equipment sized to handle small batches, and they probably already have an established customer base.

The advantage of this option is that once you get the milk to the cheese plant, your job is done. You don't have the added work of processing the milk and marketing the finished products. You are then free to concentrate on doing what probably led you to milking sheep in the first place: being a farmer. The disadvantage is that you don't get a share of the profits of the finished products.

A variation on this approach if you are lucky enough to have a cheese plant near you is to contract for them to make products to your specifications under your label. You would then be responsible for the marketing of the finished product, but would not have to possess the cheese making skills and do the extra work of processing the milk. Or, you might form a partnership with the management of the cheese plant so that you sell them milk at a lower price in exchange for a share of the profits from the cheese.

The advantage here is that you will participate in the profits from the cheese. The disadvantage is the work of marketing the cheese.

The final option is to do everything yourself: Milk the sheep, and make and market the cheese. This may be your only option if you don't have a cheese plant near you. And, while this approach may ultimately be the most rewarding for some, it is by far the most difficult and expensive to accomplish.

The cost to build and maintain a processing facility can vary greatly depending on the regulations in your state, the kind of product you intend to make, and how much milk you will have to process. However, you can be sure that compared to setting up a facility to milk sheep on an established farm, building a creamery is an expensive undertaking. Of course you will also have to learn to make cheese too if you don't already know how.

Before starting such an undertaking, you must have a good knowledge base of the potential market for your products and a realistic expectation of returns in the early years.

## **MARKETING FARMSTEAD CHEESES - THE VERMONT SHEPHERD EXPERIENCE**

**David Major**

**Vermont Shepherd  
Putney, Vermont**

This talk covers three elements in our experience marketing farmhouse cheese at Vermont Shepherd and Major Farm: how we market now, and a brief history of how we got here, lessons we have learned about the nature of today's markets, and a description of the tools and tricks we use to sell our cheese.

### **Vermont Shepherd Today**

Currently we market about 30,000 lbs of cheese per year. Half of this is Vermont Shepherd Cheese made from the milk of our own sheep. The other half are two cows' milk cheeses we make together with a nearby cow dairy. These cheeses we call Putney Tomme and Timson. Our three cheeses are aged natural rinded wheels that ship well.

Except for a few "Open Caves" per year, we tend to discourage on-farm purchases. Instead we ship almost all our cheeses, most via UPS. 20% of our sales are retail sales to mail order customers, 60% of our sales are wholesale sales direct to stores and restaurants, and the remaining 20% are to distributors who then resell the products.

While we do almost no advertising, we do participate in a number of state, regional, and national promotional events run by the Vermont Cheese Council, Great Cheeses of New England, The American Cheese Society, Slow Foods, and others. In addition, we work with individual accounts for special promotions. Also, we run mail order or email promotions to all our customers maybe 3 times per year.

Depending on our market - retail, wholesale or distributor - we receive between \$18.50 and 11.00 per lb for the sheep cheese, and \$15.50 and 8.00 for our cow cheeses. We sell all we make, though the wheels shrink about 15% in maturation and between 2% and 20% wind up spoiled, depending on the variety and the year.

Our markets are far and wide, with 17% sold within state, 63% sold across the rest of the northeast, and 20% sold elsewhere in the country, all the way to the West coast.

### **A Brief History**

We started making cheese in the late 1980's in order to add value to our sheep's milk and find some way of getting it to the marketplace. In our first experiments we attempted to market at the local farmers market. The feedback was sufficient to let us know we should continue experimenting. Our break came in 1993 when we received an award from the American Cheese Society for the best farmhouse cheese in the country. Since then our accounts have increased gradually to

include stores and restaurants around the country, so that we now have over 200 active accounts. In 1999 we attempted to shift most of our accounts over to distributors. That turned out to be a disaster. In 2000 we went through a dismal period when the quarantining of two flocks in Vermont for possible mad cow disease - flocks unrelated to and hundreds of miles from our own - caused enough publicity to have a huge impact on our sales. Also in 2000, we put up a website with the ability to take credit card sales. It took over a year, but now the website is responsible for the bulk of our retail sales.

### **Lessons from the Marketplace**

- 1) The market is divided into retail, wholesale, and distributor accounts, with retail paying the highest for your product and distributor paying the least. Be sure you have at least three different prices on each product you sell, even if you do not see why from a cost-to-produce point of view. In an ideal world, the distributor price is the price you need to get for your cheese; the wholesale price is the distributor price plus 20%, and the retail price is close to twice the distributor price.
- 2) To start, market small and market local. Farmers Markets, Food Co-ops, and local groceries (if you have any left) are excellent for this. Your product must be able to sell well locally if it is to stand a chance elsewhere.
- 3) The scale of the market must be on the same scale as your farm. Just as a pedestrian cannot walk on the interstate and trucks cannot travel on the sidewalk, a farmhouse cheese cannot be marketed to Walmart or any other big food retail chain. This presents a problem for us small farmers, since most of the population spends most of their food dollar in international chains owned by a very few companies. Recent retail consolidation has eaten up most of our markets. As an example, we used to sell regularly to Dean and DeLuca in NYC. They've merged and expanded to become a couple of dozen stores in the US and Japan with central distribution in Kansas City. They no longer buy from us regularly. We tried to work with a national distributor. They sent us a letter saying that they were building a new warehouse to service us better. But it was expensive to build, therefore they were taking 10% off of all our overdue invoices. Another distributor sent us a bill in September for half of a large order of our cheese they received the previous year, saying it had gone bad in May. They deducted the amount from outstanding invoices and to top it off, billed us for previously unknown promotional events they claim to have staged on our behalf. The lesson we learned is: it takes a staff of lawyers and accountants to deal with the shenanigans of the large scale, increasingly consolidated retail and distribution world. If you haven't got that kind of staff and the volume of product to support it, then do not bother pedaling your product to the large scale chains and distributors. Stick to the farmers markets, food co-ops, neighborhood groceries, delis, and general stores, and independent restaurants.

## Tools and Tricks

Over the years we have discovered several tricks that help us market our cheeses. First off, we had to get to the point where our cheese was high quality and consistent. And we needed an identity. Our identity comes in part from the story of how we came to make Vermont Shepherd. It's a love story. My family has sheep. Cindy's family has a dairy. We fell in love and made a sheep dairy. Until we had the quality and identity, our biggest market was the manure pile. Quality and identity are prerequisites to successful marketing. Beyond them, we found several other things to be helpful.

- We participated in the state and national cheese organizations, like the American Cheese Society (ACS) and the Vermont Cheese Council. With support, these organizations can provide excellent opportunities for showing your product to restaurateurs and shop owners.
- We enter our cheeses in cheese contests sponsored by ACS and the Wisconsin Cheesemakers Assoc. The feedback from the contests is usually very good, as is the exposure your product gets if it is of reasonably good quality.
- For us, marketing is personal. We try to get to know the buyers, keep track of their names, support them in their promotional projects, offer to do cheese tastings for them, and invite them to visit us.
- Make a big deal of the farm artisan nature of the product. The type of product we are marketing is a very very rare thing these days. We do this by keeping track of the pasture, the weather, and any other relevant facts about the milk, animals, and cheese. We write this up on what we call Batch Cards, and we send out one with every wheel. This helps the restaurateur or shop keeper with his or her own story. Also, we use hay or washed wool as packing material. These materials are relatively cheaply produced on our own farm, they smell good, are biodegradable, and convey the right image.
- We have found it important to have a supply of pictures - ideally digital ones - and written descriptions of our cheeses for stores and trade publications when they want to promote our product.
- The internet has been a good tool for us to link directly with our retail customer. Our secure website provides us with hundreds of dollars a week in retail sales, The trick here is getting your name and identity out there so that customers know to type in your name on their computers.

We've been marketing our Vermont Shepherd Cheese for over a decade. It is a challenge in the increasingly consolidated world of food retail, but it can be done with the right combination of quality product, identity, and persistence.

# MARKETING LAMBS, CULL EWES AND WOOL FROM THE SHEEP DAIRY FLOCK

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Dairy sheep farmers have three potential sources of income: milk, meat, and wool. Sheep milk and possibly milk products presumably should be the most profitable part of the enterprise and, therefore, receive the most attention. How much dairy sheep farmers seek to capitalize on the by-products of the milking operation depend on several factors such as:

- their interest in diversification,
- their available time and other resources.

Wool must be removed as a normal management practice. Although in recent years the world and national market conditions for wool have been dismal, the situation appears to be improving. New government programs may also change this financial picture somewhat, but profit for raw wool is likely to remain modest. Steps can also be taken to upgrade the profitability of the wool by further processing and through marketing efforts. Before embarking on such an investment of time and effort, however, thought should be given to the purpose of the farm. Unless a family member has a strong interest in further processing the wool, it should be marketed through a wool pool to a commodity market. With an average yield of 8 lb of wool per ewe and prices ranging from \$0.10 to \$1.00 per pound, the return per head for wool will range between \$0.80 and \$8.00 per ewe.

Cull ewes are a necessary by-product of any sheep operation. Cull ewes often command higher prices in mid-winter or associated with the Muslim holiday of Id al Adha (The Festival of Sacrifice) which will be on 12 February 12, 2003 and 1 February 2004. Check the Northeast Sheep and Goat Marketing Program web site ([www.sheepgoatmarketing.org](http://www.sheepgoatmarketing.org)) for future dates. Thus, if pasture or feed resources and management time are available, it might be profitable to accumulate cull ewes for sale at times when the price will be higher. Otherwise, cull ewes probably should be marketed through a dealer or an auction at the time they are culled.

Most cow dairy operations ship calves not kept for replacements to market shortly after birth. This is possible because several markets exist for calves, namely, bob veal, veal growers, replacement heifers, and beef. Similar markets are not available for newborn lambs. As a consequence, some additional investment of milk replacer and time must be made to bring lambs to a marketable size. A thumb rule is that one pound of milk replacer powder is required per pound of gain. Milk replacer powder purchased in quantity has a current cost of about \$1.00 per pound. Newborn 8-pound lambs that are first fed bottled colostrum (letting the lamb suckle the ewe for colostrum is not recommended because it then is more difficult to get the lamb to suck from an artificial nipple) and then raised artificially until four weeks old should gain 0.7 lb per day for a total weight gain of 19.6 pounds on \$19.60 of milk replacer. At 27.6 pounds, those lambs will be acceptable market weight for some

<sup>1</sup> Bob Melchior was the Marketing Coordinator for the Northeast Sheep and Goat Marketing Program at the time of his sudden and unexpected death on 8 August 2002. Bob had started this paper before he died.

hothouse lamb markets (Figure1). They can also be fed at a cost of about \$0.35 per pound of gain to heavier weights for heavier hothouse lamb markets or for other markets (Figure1). Assuming the value of a non-replacement lamb in a dairy sheep operation at birth is zero, and with good hothouse lambs bringing \$1.50 to \$2.00 per pound or more, milk replacer is certainly worth the investment. How, then, should the dairy sheep farmer go about marketing lambs to ensure that they bring the highest net return?

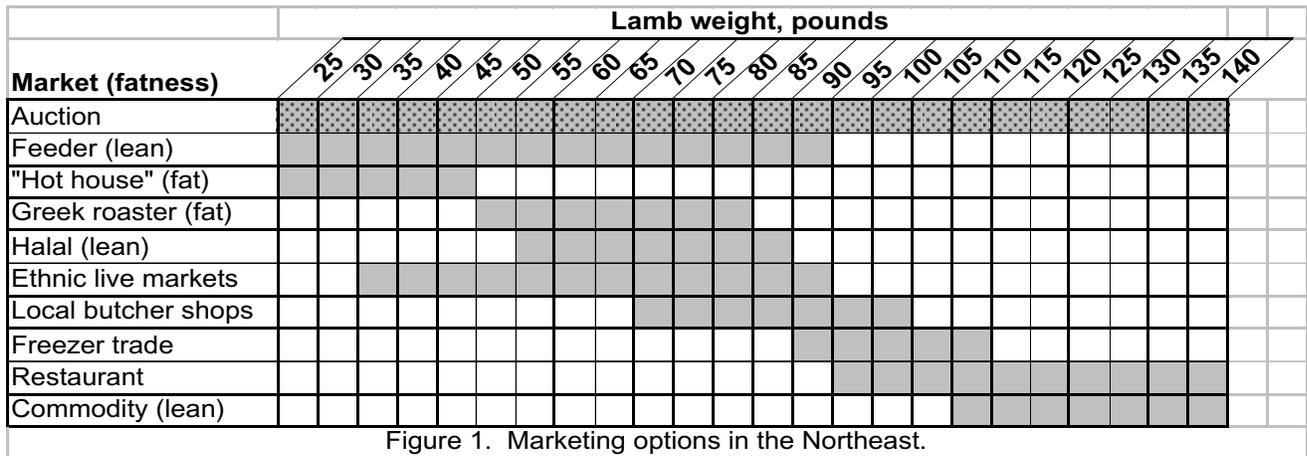


Figure 1. Marketing options in the Northeast.

The lamb market is segmented with the strongest consumption coming from various religious and ethnic communities. Each group has its own preferences on the size and type lambs they want to consume (Figure 1). Thus, the producer should know the market in order to supply what is needed or be willing to market through a dealer who knows the best markets.

Auction markets are readily available but many do not specialize in sale of sheep and lambs. For example, most of the auction markets in the northeastern United States specialize in marketing cull dairy cows and baby calves. Unless a dairy sheep farmer is near a regional auction market that specializes in a large volume of lambs and sheep, other marketing options should be considered.

One option for dairy sheep farmers located near large urban centers is to market individual animals directly to consumers. Recent immigrants like to make the trip to the farm and choose their own animals. They may request permission to slaughter the animal on the farm which, if it is convenient for the farmer to provide the facilities, adds value to the sale.

The two keys to marketing young lambs to other markets are uniformity and numbers. Whether marketing direct to a volume customer or through a dealer, enough animals to fill the trailer or truck are necessary to attract buyers. Usually, buyers want to supply a specific market so the animals need to be uniform in weight and fatness.

An alternative to having large numbers is to provide smaller groups of uniform animals throughout the year. For example, the Northeast Sheep and Goat Marketing Program initiated a market pool consisting of a group of five lamb producers and an ethnic meat retailer in New York City. The pool supplies the retailer with 10 to 20 lambs per week all year long at a fixed price per pound of carcass

weight. The combined producers represent a total ewe flock of about 1200. All are on accelerated lambing programs and all but one also service other markets.

The pool operates by sending the lambs to a rural slaughterhouse that has agreed to a flat charge to kill and deliver the lambs to New York City. The producer pays the slaughter and New York City delivery charge up front when the lambs are delivered to the slaughterhouse. After the slaughterhouse makes delivery, the retailer mails payment for the lambs, based on the carcass weights provided by the slaughterhouse, to the pool manager, who in turn, forwards the gross amount received to the producer.

The product being marketed by the pool is a fat lamb carcass ranging from 30 to 40 pounds. In the restaurants, the carcasses are roasted on a spit over a bed of coals. Meat for meals is sliced off the roasting carcass based on the customers' preference of cuts.

The retailer uses considerably more of these lambs than the 10 to 20 being supplied by the pool. The balance is supplied by slaughterhouses that buy at regional auctions or from dealers. The slaughterhouses have difficulty finding a continuing supply of these specialty lambs, especially from January through June. In addition to roaster lambs, the store purchases finished western lamb for retail cuts and other specialty lambs (hothouse) for holidays and by special order. Thus, there is considerable room for expansion with additional roaster lambs or with hothouse lambs. Price considerations rule out supplying large lambs like those obtained from the West. As more direct marketing pools develop, dairy sheep farmers could participate in them at least part of the year.

Dairy sheep farmers who manage their ewes for once a year lambing in the spring meet the requirement for uniformity and numbers of lambs for marketing in large groups. Thus, they have several marketing options. One is to sell feeder lambs but that market is not as lucrative as the several options for lighter weight meat animals such as hothouse, Greek roaster, halal, and other ethnic market lambs. To access these markets, producers need either direct connections with buyers or the services of a dealer. Many buyers in the Northeast are listed in the web site directory of the Northeast Sheep and Goat Marketing Program ([www.sheepgoatmarketing.org](http://www.sheepgoatmarketing.org)).

The markets for heavier lambs shown in Figure 1 are local butcher shops, freezer trade (selling cut, wrapped, and frozen carcasses directly to consumers for their freezers), restaurants, and the traditional commodity market for "finished" lambs. Because the gross return per animal at heavier weights often is not much more than that for the specialized markets for lighter animals, usually they are not as profitable. In addition, most sheep dairies will not have the volume of lambs necessary to compete with traditional western feedlot lambs available through commodity markets.

Dairy sheep farmers have many options for marketing their non-dairy production. Which options they choose depends upon the additional time and resources available for adding value to wool, cull ewes, and lambs. Producers should spend some time investigating options available in their regions. Farms located near urban areas with large populations of first and second generation immigrants should ethnic markets for lambs and cull ewes. Educational resources, current market information, and a directory of buyers in the Northeast are located at the [sheepgoatmarketing.org](http://sheepgoatmarketing.org) web site.

# NUTRITIONAL STRATEGIES TO IMPROVE LACTATION PERSISTENCY IN DAIRY EWES

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## INTRODUCTION

Milk production is largely dependent on the shape of the lactation curve. Relevant elements of the lactation pattern are the peak yield, which represents the maximum milk yield during the lactation, and the lactation persistency, which expresses the ability of animals to maintain a reasonably constant milk yield after the lactation peak (Figure 1). Thus, persistent animals are those that show flatter lactation curves. Several measurements of persistency have been proposed (Broster and Broster, 1984; Gengler, 1996): the rate of fall of milk yield per week or per month; combinations of parameters of mathematical functions used to model the lactation curve; the variation of test day yields throughout the whole lactation or part of it; the proportion of total milk yield achieved in a certain period (e.g. second half of lactation). However, none of the above mentioned measurements seems to be able to become the reference method (Grossman et al., 1999). For example, the definition of persistency as the rate of fall of milk yield per unit of time can be misleading if the absolute level of production is not considered. Usually curves with high peak yield show low persistency because the rate of milk yield declines faster in animals that have a fast milk yield increase after calving (Figure 1). Thus in this review, we will consider persistency in a broad sense, and we will analyze the nutritional and non-nutritional factors that affect and limit milk production in mid-late lactation in sheep.

In dairy cows the correlation between peak yield and lactation yield (+.78) was higher than that observed between persistency and lactation yield (+.34) (Galton and Merril, 2002). In dairy ewes as in cows, milk yield in the first month of lactation, i.e. when the lactation peak is attained, was highly correlated with total milk production per lactation (Rossi, 1976). Thus peak yield seems to be more important in determining the total lactation yield than persistency even though, as already said before, these results should be further confirmed by comparing individual shapes of the lactation curve within production levels. Nevertheless, more persistent lactation may be desirable due to the relationships between this trait and reproduction efficiency, health status and feed costs (Dekkers et al. 1998; Grossman et al., 1999). For example, animals with very high peak yield are not able to consume adequate amounts of nutrients in the first part of lactation. This results in negative energy balance, reduced reproductive efficiency and increased susceptibility to diseases (Jakobsen et al., 2002; Swalve, 2000). By contrast, animals with flat curves are less subjected to metabolic stress in early lactation and have a more constant pattern of energy requirements throughout the lactation, allowing the utilization of cheaper feeds (Solkner and Fuchs, 1987; Dekkers et al., 1998).

Very long lactations are not desirable either, because a non-lactating (dry) period prior to parturition is required to restore mammary gland secretory tissue for milk production in the subsequent lactation. In general a period of 50 days of dry period is recommended in cows, even though in goats the omission of the dry period between lactations did not reduce subsequent milk production (Fowler

et al., 1991). In sheep very long lactations are rare and in general the dry period is sufficiently long to restore mammary gland secretory tissue.

Lactation curves of sheep show several peculiarities that are the result of biological and, above all, management factors (Figure 2; Cappio-Borlino et al., 2002). In Mediterranean countries, where there is the world's largest concentration of dairy sheep, reproductive and productive cycles are strictly seasonal, being synchronized with the availability of natural pasture; as a consequence, milk production is strongly influenced by environmental factors (Macciotta et al., 1999). Moreover, in most cases the milk of the first month of lactation is suckled by the lamb. This has reduced the availability of milk yield data for the ascending phase of lactation, which has been little studied.

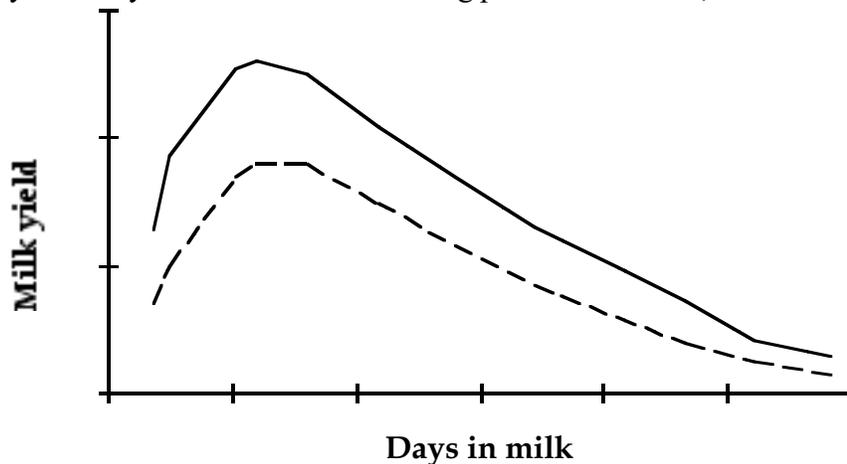


Figure 1 - Typical lactation curves of ruminants. The higher curve (continuous line) has higher peak milk yield and lower persistency than the second (dotted line).

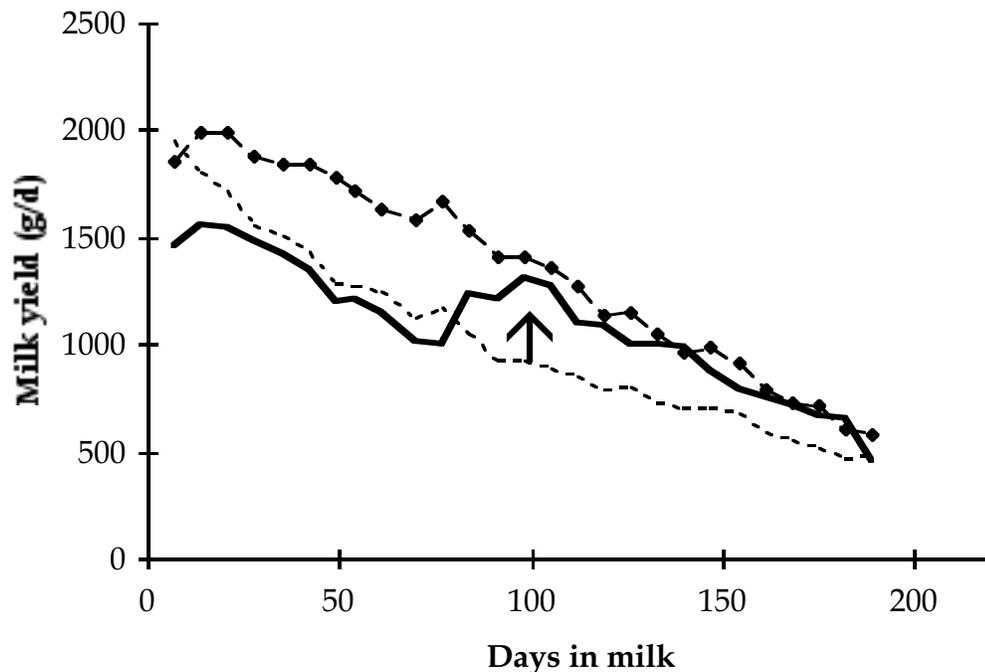


Figure 2 - Lactation curves of Mediterranean sheep. The arrow indicates a “false” lactation peak (continuous line curve) that usually occurs in the spring, when a large amount of pasture is available after a period of scarce availability (Cappio-Borlino et al., 2002). The highest curve is that of well-fed sheep and the dotted one represents a lactation curve without peak.

The lactation peak is expected within 3-4 weeks after lambing, i.e. in winter for mature ewes, but it is often smoothed due to adverse environmental conditions, such as low temperatures and scarce feed availability. On the other hand, the favorable climatic conditions that can be found during spring and, especially, the large availability of pasture usually result in a “false” lactation peak in the second half of lactation (Figure 2). This behavior has also been observed in dairy cattle under grazing management systems (Garcia and Holmes, 2001).

A common feature of dairy sheep lactation curves (30 to 50% of the cases) is the absence of the lactation peak (Cappio-Borlino et al., 1997a). Such a dimorphism could be the result of genetic and nutritional causes, because the diet is unable to meet the nutritional requirements of the ewe. Similar lactation patterns have been observed in dairy cattle (Broster and Broster, 1984; Shanks et al., 1981).

## PHYSIOLOGY OF LACTATION PERSISTENCY

The pattern of the lactation curve is influenced by the number of secretory cells in the mammary gland and by the synthetic activity of each secretory cell. Growth and differentiation of the glandular epithelium during puberty and pregnancy are important determinants of the total area of secretory epithelium and consequently of milk yield. After parturition, the maintenance of secretory epithelium is the critical point determining persistency of lactation and total milk yield. Knowledge of the physiological and environmental factors that influence the number and the activity of mammary secretory cells is necessary to determine a proper strategy for maintaining lactation.

As lactation progresses, the secretory cells gradually regress from a state of active synthesis and secretion to a non-secretory state through a process called “involution”. Considering the typical lactation curve (Figure 1), gradual involution starts around peak lactation and continues up to the time when the animals are dried off. Because milk yield is the result of the number of secretory cells and of the secretory rate of each cell, gradual involution takes place through a decrease in the number of mammary cells or a decrease in their activity. Maintenance of milk synthesis and secretion is controlled by a balance of both systemic and local regulatory factors.

### Systemic factors

The systemic factors involve hormones such as prolactin (PRL) and growth hormone (GH) that have an important role in maintaining the lactation; changes in their circulating levels affect the rate of secretion of milk. As lactation progresses, the levels of GH (Akers, 2002) and PRL (McMurtry et al., 1975) decrease, causing a reduction of milk synthesis. The influence of these hormones in reducing involution is mediated by the insulin-like growth factor-I (**IGF-I**) (Tonner et al., 2000), a hormone which is well known to increase milk yield.

The GH, whose receptors are not present in the mammary gland, exerts its positive effects on milk yield indirectly by stimulating IGF-I synthesis and secretion (Figure 3); IGF-I receptors have been identified in the mammary gland of sheep (Akers, 2002). On the other hand, the positive action of PRL in reducing involution of mammary cells is related to the suppression of insulin-like growth factor binding protein-5 (IGFBP-5) production in the mammary tissue, which

otherwise would inhibit IGF-I secretion (Tonner et al., 2000). The secretion of IGF-I is regulated by the nutritional status of animals. For example, plasma IGF-I concentration increased when the intake of high-energy and high-protein diets increased (McGuire et al., 1992). Both the increase of the frequency of feeding with concentrate supplements from one to three times a day and the improvement of forage quality increased plasma IGF-I concentration in ewes in late pregnancy (Chestnutt and Wylie, 1995).

**Local factors**

In addition to systemic factors, local factors, such as the feedback inhibitor of lactation (FIL) and the plasminogen-plasmin system, are involved in the involution process.

*Feedback inhibitor of lactation*

The accumulation of milk in the mammary gland can accelerate the involution process and reduce lactation persistency. In sheep, we observed that hourly milk secretion rates tend to decrease as the milk in the mammary gland accumulates (Figure 4; Nudda A. and Pulina G., unpublished).

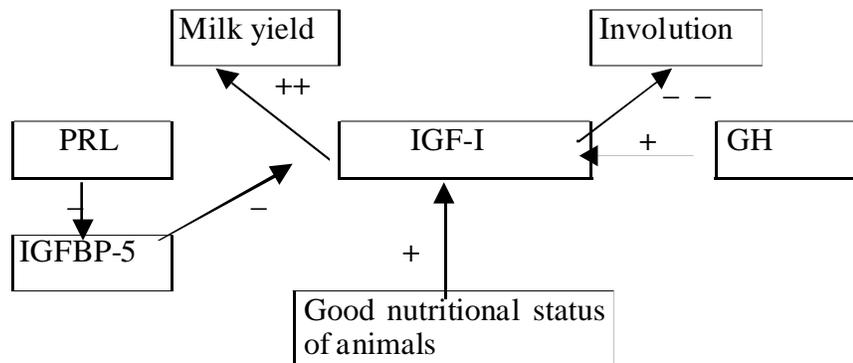


Figure 3 - A schematic description of the systemic factors that influence secretory cells activity and milk yield (+ positive effect; - negative effect).

The factor involved in the reduction of milk secretion has been identified by Wilde et al. (1987) as a peptide named feedback inhibitor of lactation (FIL), synthesized by mammary epithelial cells and secreted with the milk into the alveoli. As time from last milking increases, milk accumulates in the alveoli with this peptide, which causes the progressive reduction of milk synthesis and secretion. Therefore, frequent removal of milk (and consequently of the FIL) from the mammary gland reduces local inhibitory effects. The capacity of the mammary cistern can also have an important role in the reduction of local inhibitory effects on milk secretion due to milk accumulation with extended milking intervals. For example, ewes that stored a large proportion of milk in the cistern were able to tolerate the extension of milking interval up to 16 hours without reduction of milk secretion (McKusick et al., 2002; Pulina et al., 2002).

The local regulation of milk synthesis and secretion was firstly observed in goats (Wilde and Knight, 1990) and cows (Stelwagen and Knight, 1997), in which unilateral alteration of the frequency of milking affected only the treated gland: the increase of milking frequency from 2 to 3 times per day in one udder increased milk yield without effects on the milk yield of the controlateral gland, which continued to be milked normally (twice per day).

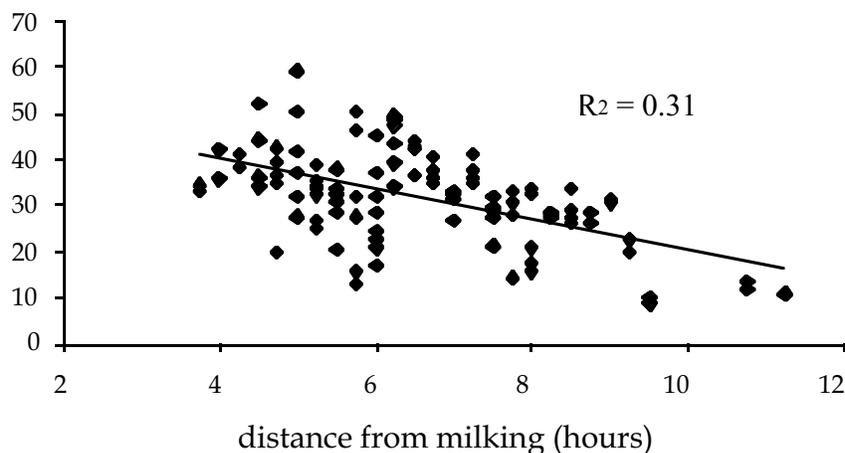


Figure 4 – Reduction of milk secretion rates due to the increase of the interval between milkings in secondiparous Sarda ewes (Nudda A. and Pulina G., unpublished).

The local regulation of milk secretion was also recently observed in dairy ewes in which the unilateral reduction of the milking frequency from twice to once a day affected only the treated gland (Nudda et al., 2002a). An important observation in this experiment was that the gland milked twice per day did not show an increase in milk production due to the greater availability of nutrient supply caused by the suppression of one milking in the opposite gland. Thus, availability of substrates for milk synthesis was not the only limiting factor in milk synthesis. This hypothesis is fully confirmed by our recent experiment on well-fed primiparous ewes in which one udder half was milked twice a day, whereas in the opposite udder half milking was completely suppressed for one week. The milk yield of this udder half was 50% lower than the milk yield obtained from ewes in which both udder halves were milked twice a day (618 vs 1221 g/d - unpublished; Figure 5). In brief, the increase in availability of precursors (which were not utilized by the udder half in which milking was suppressed) did not cause an increase of their uptake for milk synthesis by the regularly milked udder half. Because the nutrients available were sufficiently high to satisfy the maximum potential synthetic rate of each cell, we concluded that milk yield was conditioned mainly by the number of cells active at the moment in which the experiment was carried out rather than the synthetic rate of each cell.

In practice, the regulation of milking frequency and of the interval between milkings in well-fed animals can be a way to manipulate milk secretion and retard the involution of secretory cells.

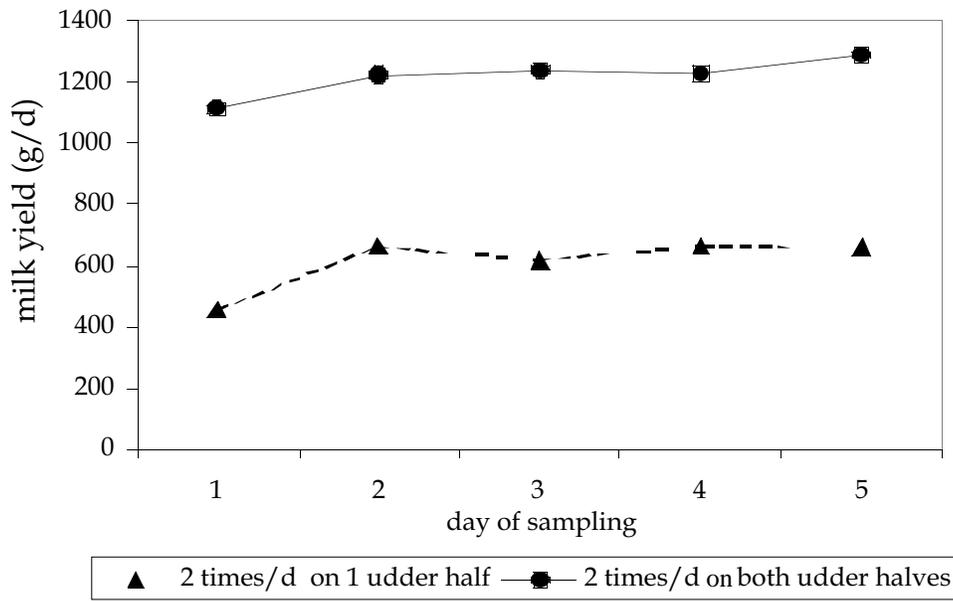


Figure 5 - Milk yield of mammary glands in which both udder halves were milked twice a day or only one udder half was milked twice a day and the other was not milked (Nudda A. and Pulina G., unpublished data).

#### *Plasmin-plasminogen system*

Plasmin is the predominant protease in milk, and it is mainly associated to casein micelles, which represent its substrate of action. Plasmin is responsible for the hydrolysis of  $\alpha$  and  $\beta$  casein in milk. Both plasmin and its precursor, plasminogen (PG) are present simultaneously in milk. The plasminogen is converted into active plasmin by the action of the plasminogen-activator (PA), whose activity is reduced by PA inhibitors (PAI) (Politis, 1996). The plasmin-plasminogen system seems to be involved in the events that occur during the gradual involution of the mammary gland (Politis, 1996). Indeed, the activity of plasminogen and plasmin increases in milk as lactation progresses. A simplified model of the processes that involve the plasmin-plasminogen system in the involution of secretory cells is shown in Figure 6.

*The plasma insulin-like growth factor (IGF-I), which acts as a mediator of the growth hormone (GH), and the nutritional status of the animals also play a role in decreasing PA, probably throughout the stimulation of PAI (Padayatty et al., 1993).*

It is well known that administration of exogenous GH in sheep (Baldi et al., 1997; Baldi, 1999; Chiofalo et al., 1999), cows (Politis et al., 1990), and goats (Baldi et al., 2002) increases milk yield and lactation persistency and reduces plasmin activity, probably through its mediator IGF-I. The nutritional status of the animals also plays an indirect role in regulating PAI. Nutrition can influence the involution process through the regulation of plasma IGF-I concentration which, as said before, increases in well-fed animals.

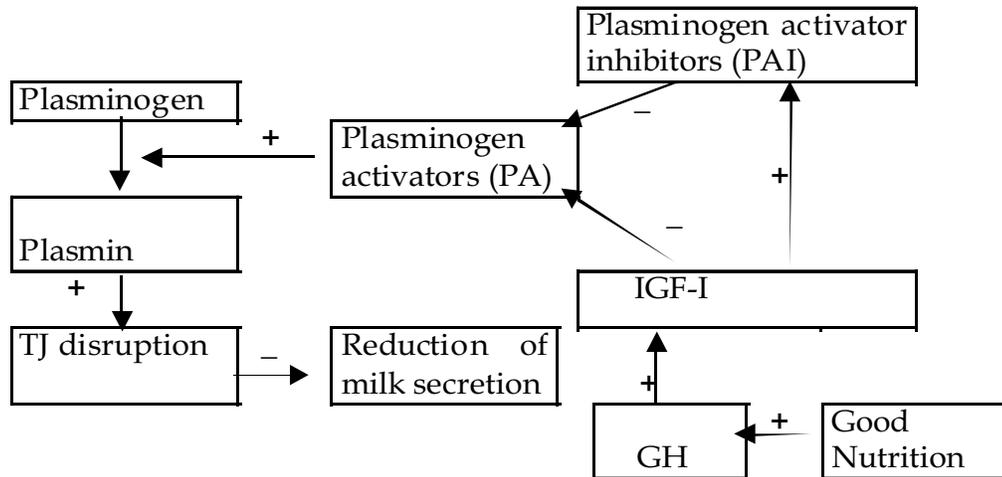


Figure 6 – A schematic representation of the mechanisms of action of the plasminogen-plasmin system on cellular involution.

*Disruption of tight junctions integrity* The involution of mammary secretory cells is triggered by the disruption of tight junctions (TJ) between adjacent cells. A schematic representation of the mechanisms involved in TJ disruption is presented in Figure 7. The TJ are structures which encircle the cells and fuse adjacent cell membranes forming a barrier between blood and milk. The TJ are connected with the cytoskeleton, a network of micro-filaments that is probably involved in the secretion of the neo-synthesized milk components from the secretory cells into the alveolar lumen. During lactation, or in conditions in which the integrity of TJ is maintained, milk precursors reach the alveolar lumen passing through the secretory cells (the transcellular route). During involution (but also in other conditions such as pregnancy, presence of mastitis, and extended milking interval) the TJ become leaky and permit the passage among cells of blood precursors that have to reach the alveolar lumen (the paracellular route). Because of the above mentioned connections between TJ and cytoskeleton, the leakiness of TJ affects cytoskeleton activity, reducing its dynamic properties in the transfer of neo-synthesized milk components towards the apical membrane of the mammary secretory cells (Mephram, 1987). The reduced secretion of milk components inhibits further synthesis and can predispose secretory cells to involution.

The impairment of TJ, which cause the activation of the paracellular pathway, allows the passage of substances among epithelial cells, causing an increase of Na in milk and the passage of lactose into the blood (Stelwagen et al., 1994). A high Na/K ratio in milk has been associated with the mechanisms that reduce milk yield when the permeability of mammary TJ is increased (Allen, 1990).

Tight junctions can be damaged by: the increased activity of plasmin, as lactation progresses, in the case of mastitis or prolonged milking intervals; the massive migration of somatic cells (leukocytes or white blood cells) from blood to mammary gland to defend the tissue from pathogens in case of inflammations (mastitis); the stretching caused by excessive accumulation of milk (Mephram, 1987) with long milking intervals (Stelwagen et al., 1994).

It appears, then, that mammary involution is controlled by local and systemic factors with highly integrated mechanisms of control.

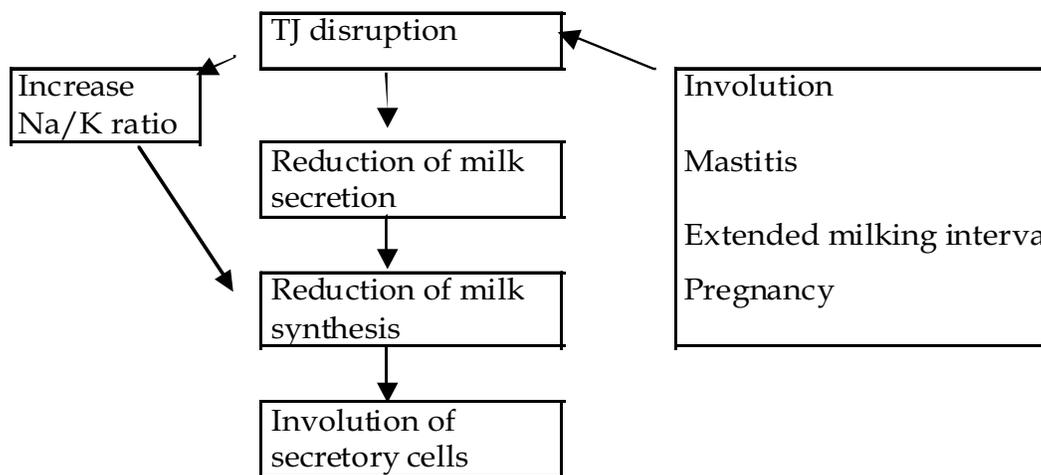


Figure 7 - A schematic and simplified representation of the mechanisms associated to tight junction disruption during cellular involution.

## NON-NUTRITIONAL FACTORS AFFECTING PERSISTENCY OF LACTATION

A proper definition of nutritional strategies to improve lactation persistency requires that the non-nutritional factors that affect lactation persistency are well defined.

### Genetics

In the present scenario of animal breeding strategies, there is a renewed interest in the persistency of lactation because the maximization of yields does not necessarily represents the best economical choice. The improvement of profitability of animal production through the reduction of production costs seems to be a reasonable option. A relevant drawback for the practical implementation of persistency as a breeding goal in dairy species breeds is represented by the great difficulty in identifying an objective measure of this trait. The several approaches that have been suggested for measuring persistency of lactation can be divided into (Gengler, 1996; Grossman et al., 1999; Jamrozik et al., 1998; Solkner and Fuchs, 1987): i) measures referring to different combinations of parameters of mathematical functions used to fit lactation curves, ii) measures based on ratios between accumulated yields and iii) measures derived from variations of test day yields; iv) days in which a constant level of production is maintained. However, none of these measurements became the standard method. Recently, a multivariate approach has been suggested to estimate an objective quantitative index of lactation persistency (Macciotta et al., 2002). Whatever index is used, the heritability of lactation persistency is low to moderate (0.10-0.30), indicating the possibility of selecting for the shape of the lactation curve (Chang et al., 2001). However, this should be made by carefully considering the relationships between persistency and yield: some results seem to indicate that the flatter the curve, the lower the total yield (Ferris et al., 1985); however, at the same level of production, relevant differences in the shape of the lactation curves were found (Macciotta et al., 2002). Thus, a reasonable approach to the selection of lactation persistency should start from the definition of an aggregate genotype that includes level of production, shape of the lactation curve and, possibly, udder morphology.

## Lambing season

The effects of the lambing season on persistency have been attributed mainly to seasonal differences in pasture availability and quality.

In Mediterranean regions, milk yield was highest in ewes that were pregnant during the spring, when there is high pasture availability (Cappio-Borlino et al., 1997b). High pasture availability had a positive effect on the differentiation of udder secretory cells and on the accumulation of body reserves during sheep pregnancy (Chestnutt and Wylie, 1995).

A superimposed effect of forage availability is the photoperiod length. In Mediterranean areas the lactation occurs during the period in which day length increases. As observed in dairy cows, the increase of the hours of light seems to improve milk production and feed intake (Bocquier et al., 1997). This effect was evident when the treatment lasted more than 30 days and may be explained by the higher feeding activity of animals exposed to supplementary light. Indeed, sheep submitted, for a short period, to sharp changes in day length had a depression in milk production (Pulina et al., 2002).

## Parity order

The persistency of lactation was higher for ewes during first lactation compared to subsequent lactations (Figure 8). This was observed in the Valle del Belice (Cappio-Borlino et al., 1997b), Sarda (Carta et al., 1995) and Lacaune (Barillet, 1985) dairy ewes. Lesser effects occur in later lactations because persistency is in general negatively correlated with peak milk yield.

Stanton et al (1992), who observed the same effects in dairy cows, suggested that this could be explained by the maturation process, which is still in progress during the first lactation. This effect is well evident until 120 days in milk, after which maturation is gradually reduced and results in lactation curves similar to those of later lactations.

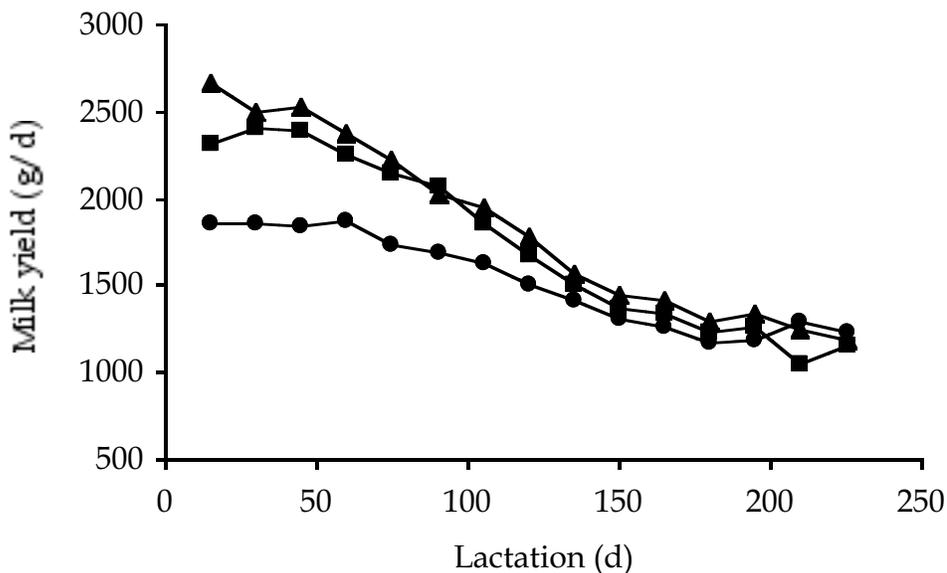


Figure 8 - Lactation curves in ewes of different parity (1 (●), 2 (■), and  $\geq 3$  (▲)); (Cappio-Borlino et al., 1997b).

### Type of lambing

Several studies have reported higher milk yield for ewes with multiple births (Table 1). This can be explained by the fact that ewes rearing multiple fetuses or with higher weight of single fetuses have higher placental weight and higher serum progesterone and placental lactogen hormones during late pregnancy (Butler et al., 1981; Schoknecht et al., 1991). These hormones stimulate greater development of the lobular alveolar structure during pregnancy and consequently greater milk production during lactation. Another factor is the more frequent suckling applied to mammary glands by twins than by one lamb, causing the removal of local inhibitors of milk secretion, such as the FIL (see previous discussion).

Table 1 – Effect of prolificacy on milk yield in different sheep breeds.

BREED	MAIN USE	MILK YIELD twins vs. single	AUTHORS
Delle Langhe	Milk	+ 10%	Ubertalle et al., 1990
Sarda	Milk	+ 11%	Pulina et al., 1993a
Churra	Milk	+ 4.5%	Gonzalo et al., 1994
Rambouillet, Columbia, Polypay	Meat-wool	+ 44%	Snowder and Glimp, 1991
Suffolk	Meat	+ 63%	Snowder and Glimp, 1991
Merino	Meat-wool	+ 46-51%	Sokolov and Kuts, 1984

The data reported in Table 1 highlight that the effects of prolificacy on milk yield are higher in meat-wool sheep than in dairy ewes. In dairy ewes the higher production of ewes rearing twins is usually evident only in the first part of lactation (Figure 9) (Pulina et al., 1993a). In meat-wool sheep an effect of prolificacy on persistency has been detected along the whole curve of lactation (Figure 10) (Snowder and Glimp, 1991). However, at least part of this difference is due to a different lactation length. Indeed, in both cases the difference between twins and single lambs was evident for about 14 weeks of lactation.

The difference in milk production associated with the type of lambing can be related to different weaning techniques adopted in dairy and non-dairy sheep. In dairy sheep the lambs are usually removed from their dams after 4 weeks of lactation (Brandano and Lanza, 2002; McKusick et al., 1999a), while in meat-wool sheep the weaning starts after two or three months of lactation (Bencini, 1993; Snowder and Glimp, 1991). When weaning takes place, milk production decreases due to less frequent udder evacuation (McKusick et al., 2001). For example, the rapid decrease of the lactation curve observed in meat-wool sheep (Figure 10) between 56 and 70 days of lactation was explained by the authors by the decreasing dependence of lambs on mother's milk due to the increased grazing activity and forage intake of lambs (Snowder and Glimp, 1991).

Regarding the influence of weaning system on milk yield, McKusick et al. (1999) reported higher commercial milk production over the entire lactation in ewes whose lambs were weaned 24 hr post-partum (twice daily milking) or had access to the mother for 15 h/d (once daily milking) than ewes that had unlimited access to their lambs (no milking) for 32 days post-partum. No differences in lactation length between the three weaning systems were observed.

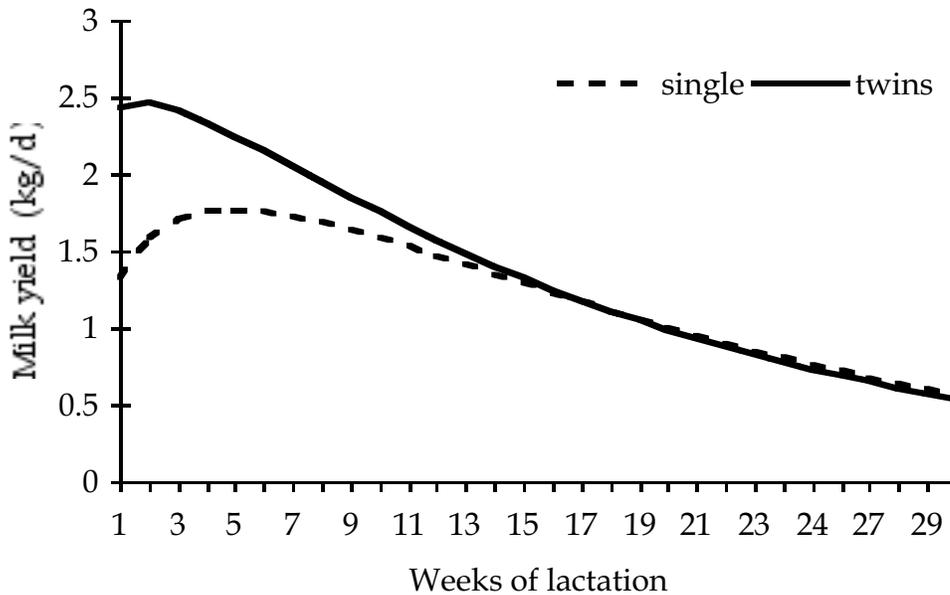


Figure 9 - Lactation curves in dairy ewes with different type of lambing (Pulina et al., 1993a).

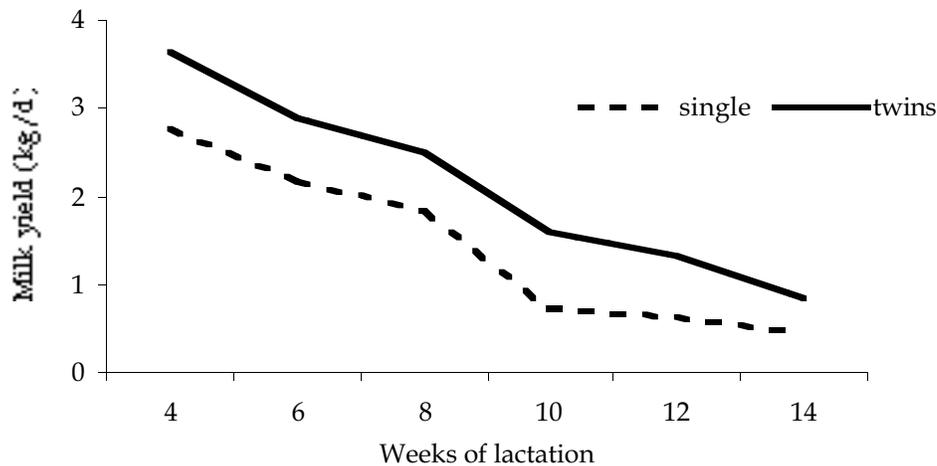


Figure 10 - Lactation curve in meat-wool sheep with different type of lambing (Snowder and Glimp, 1991).

### Milking frequency

The reduction of the milking frequency or the extension of milking intervals can accelerate the involution process and reduce lactation persistency through a mechanism that involves a local inhibitor peptide (FIL) or other systemic and local factors, as described in a previous section.

In dairy sheep, once per day milking reduced milk yield (Cannas et al., 1991; Labussière et al., 1974; Morag, 1968) in comparison with twice daily milking (Figure 11; Cannas et al., 1991) with similar intensity in dairy and meat-wool sheep breeds (Pulina and Nudda, 1996).

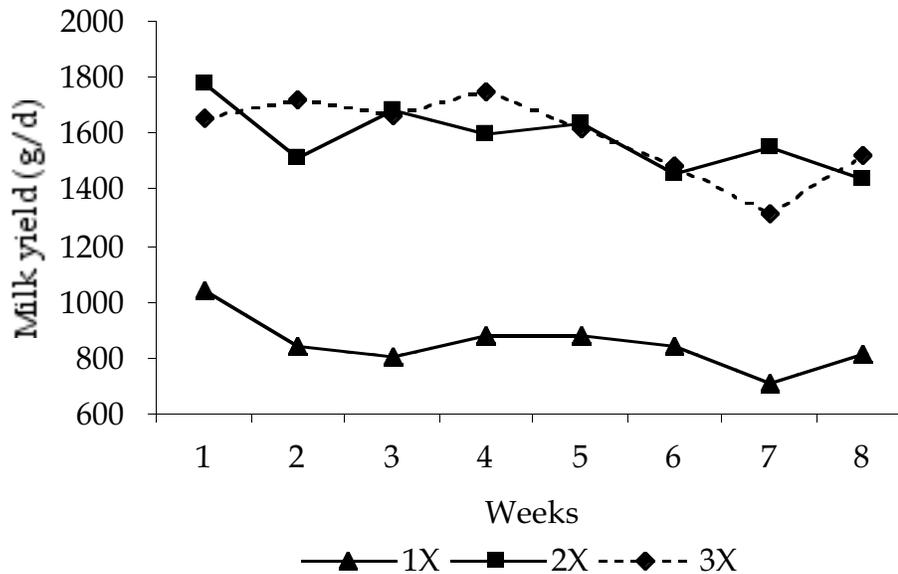


Figure 11 - Influence of milking frequency on milk yield in Sarda dairy ewes (Cannas et al., 1991)

By contrast, the effect of increased milking frequency above twice per day is higher in non-dairy than in dairy ewes (Karam et al., 1971; Bencini, 1993). This can be explained by differences in cistern storage capacity among breeds. For example, in Sarda ewes, that store a large proportion of milk in the cistern (Marnet and McKusick, 2001; Nudda et al., 2000), the increase of milking frequency from 2 times to 3 times per day had a small effect on milk yield during whole lactations (+3%; Cannas et al., 1991), while in Merino ewes the increase in milk yield was about 21% (Bencini, 1993). The difference is probably due to the smaller udder storage capacity of Merino ewes compared to Sarda ewes. Low capacity to accumulate milk during milking intervals requires more frequent milk removal from the udder, as discussed below.

### Udder morphology and cistern dimension

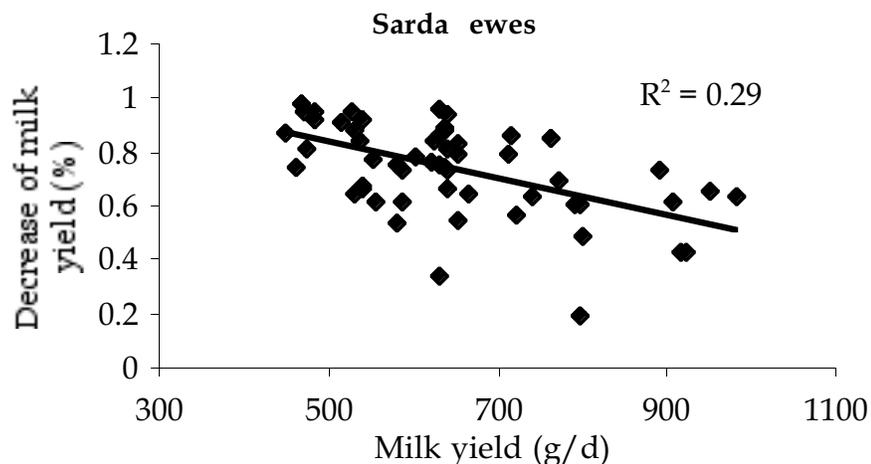
As the alveoli are the site of action of the inhibitor peptides (Henderson and Peaker, 1984), the local inhibitory factors (i.e. the FIL) affect the rate of secretion when the milk is stored in the secretory tissue, whereas they are inactive in the milk stored in the cistern. As a consequence, the action of the FIL should be of a lower magnitude in animals with a greater cistern volume, because a large proportion of the milk is stored in the mammary cistern and so the time during which the milk is in contact with the alveoli is reduced. Some studies have shown that milk production is positively influenced by mammary gland size (Bencini, 1993; Labussière et al., 1981) and cistern dimension (Casu and Labussière, 1972). In other studies, the relationship found between cistern size and milk yield was low and sometimes negative (Fernandez et al., 1995a; Gallego et al., 1983; Rebello de Andrade et al., 1989; Labussière et al., 1981). This lack of relationship between cistern size and milk yield can be the result of the method usually used to measure the size of the cistern. This method (Labussière et al., 1981) estimates cistern size by measuring the cistern height between the lowest udder point and the teat implantation line. However, the cistern is an internal structure of the udder that is neither visible nor measurable externally, and can only be measured using ultrasound techniques (Nudda et al., 2000b). Recent studies in which ultrasound technique was

used to measure cistern size confirm the high relationship between cistern dimension and milk yield in Sarda ( $r = 0.74$ ;  $P < 0.001$ ; Nudda et al., 2002b) and Manchega ewes ( $r = 0.76$ ;  $P < 0.01$ ; Rovai et al., 2002). We think that the comparisons made among breeds using the method of Labussière et al. (1981) are not reliable and do not depict the actual differences in cistern size among breeds. However, in general, non-dairy ewes have smaller cistern size than dairy ewes. This can explain their low persistency after the lambs are weaned.

The hypothesis that the action of the FIL should be of a lower magnitude in animals with a greater cistern volume has been tested in our recent experiment in which dairy and non-dairy breeds were compared. We observed that two breeds highly selected for milk production (Sarda and Awassi) responded to the reduction in the frequency of milking from twice to once a day with milk yield losses (18% to 24%) similar to those observed in Merino ewes, a wool breed not selected for milk production (Nudda et al., 2002a). A possible explanation of this result is related to the very different milk yield among the two breeds in this experiment. The ratio between milk volume and milk cistern storage capacity was probably not very different between the two breeds, explaining why the decrease in milking frequency affected them in a similar way. Indeed, the extent of milk yield reduction with once per day milking increased in proportion to the production level in the Sarda ewes (Figure 12), whereas in Merino ewes the reduction was independent from the production level (Figure 12), probably for their very low production. This is in accordance with Partearroyo and Flamant (1978), who observed, in Sarda ewes, that when passing from twice per day to once per day milking, there was a milk yield reduction of 19% in animals with milk yield higher than 600 g/d and of 2.3% only in animals with milk yield lower than 600g/d.

## NUTRITIONAL FACTORS AFFECTING LACTATION PERSISTENCY

Milk production in the first months of lactation influences the production in later months. An example of the effects of nutrition in the first part of the lactation on milk yield in the second half of lactation is reported in Figure 13 (Bomboi G., Cannas A., Molle G., unpublished).



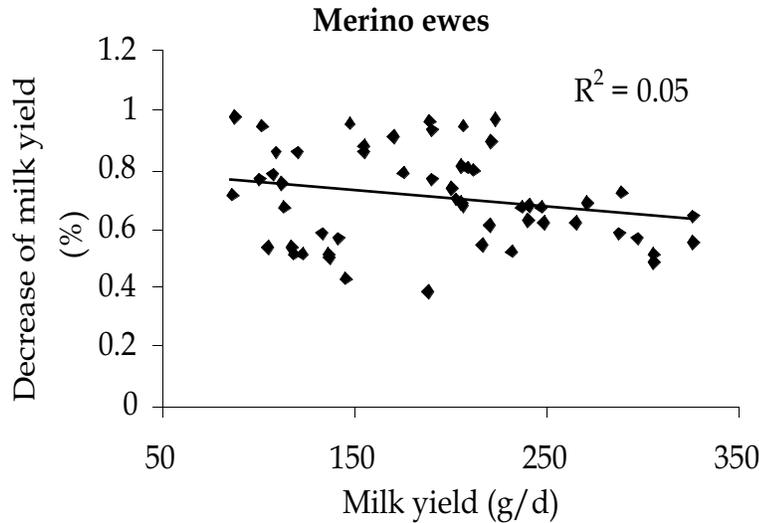


Figure 12 - Decrease in milk yield passing from two to one milkings per day according to the production level of the animals in Sarda and Merino breed (Pulina and Bencini, unpublished data).

In this experiment 60 dairy ewes were divided in 3 groups with the same mean milk yield at the beginning of the trial (9<sup>th</sup> week of lactation). Until the 20<sup>th</sup> week of lactation, each group had a different diet. One grazed ryegrass and 350 g/d of high starch concentrate as a supplement. The second group grazed the same sward but had as a supplement 350 g/d of low starch concentrate. The third one grazed on alfalfa and had as a supplement 350 g/d of low starch concentrate. The result was a significantly higher milk yield in the group that grazed alfalfa compared to the other two groups. At the 20<sup>th</sup> week of lactation all the animals were put together and fed the same diet (ryegrass pasture plus concentrate supplements). During the 10 weeks after the experiment, the group previously fed alfalfa maintained the highest milk yield and produced 210 g/d more milk than the ewes of the groups previously fed on ryegrass.

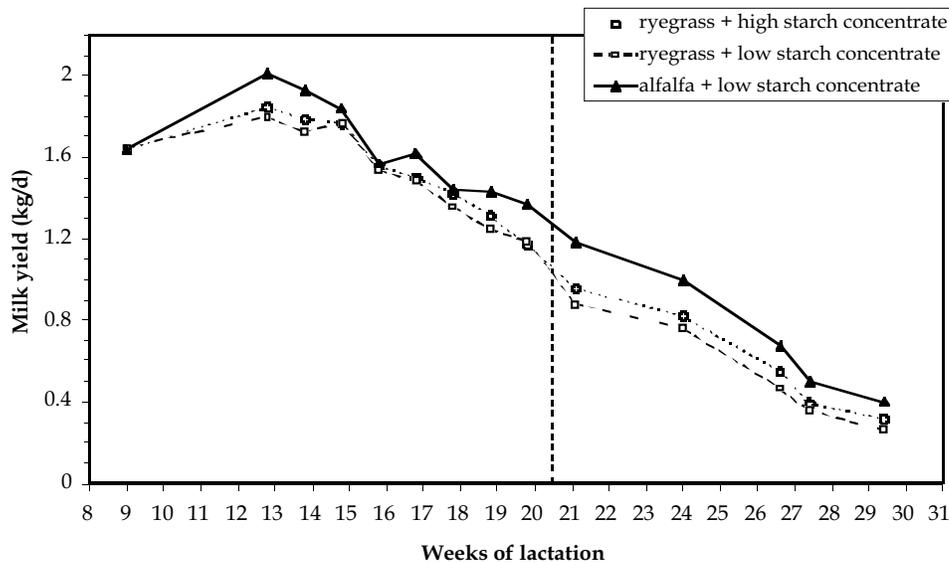


Figure 13 - Milk yield of three groups of Sarda ewes fed diets differing in the type of pasture and the quality of the supplements. The treatments were applied from the 9<sup>th</sup> to the 20<sup>th</sup> week of lactation. From the 21<sup>st</sup> to the 30<sup>th</sup> week of lactation all the ewes grazed the same pasture and received the same supplements (Bomboi G., Cannas A., Molle G., unpublished). The dotted line separates the two periods.

Due to the importance of milk production in the first part of the lactation on lactation persistency, the main nutritional strategies to improve milk yield in this phase will be discussed.

### **Nutrition during pregnancy and effect of body reserves on milk yield**

Proper nutrition during pregnancy favors the development of the secretory tissue of the mammary gland, probably as a result of the action of the placental lactogen hormone secreted by the placenta during the pregnancy. The effect is an increase in the number of mammary secretory cells and thus a higher potential milk yield. An example of the effect of nutrition during pregnancy is given by the experiment of Bizelis et al. (2000) and Charismiadou et al. (2000), who fed pregnant sheep with two different levels of nutrition (high: 110% of energy requirements; low: 90% of energy requirements). They found that the ewes fed the high level of nutrition had a larger udder at the 140<sup>th</sup> day of pregnancy (Table 2) and a higher number of secretory cells (higher DNA content).

Table 2 - Effects of two feeding levels (FL) (high: 110% of requirements; low: 90% of requirements) during pregnancy on udder characteristics at 140<sup>th</sup> d of pregnancy and on milk yield during lactation (Charismiadou et al., 2000; Bizelis et al., 2000).

	<b>High FL</b>	<b>Low FL</b>
Udder weight (kg)	2.08	1.46
Udder circumference (cm)	44.4	38.4
Teat length (cm)	4.9	4.3
Mammary gland weight (kg)	1.55	1.15
Total DNA (g)	4.97	2.82
Total RNA (g)	4.97	2.82
Total milk yield (l to 12 weeks of lactation)	114	82
Daily milk yield (l/d)	1.357	0.976
BW variations (kg in first 7 weeks of lactation)	0	+2.4

In the same experiment, after lambing all the ewes were put together and fed the same diet *ad libitum* for 12 weeks of lactation. The intake of energy during lactation was slightly higher in the first days of lactation for the ewes fed the low level of nutrition during pregnancy. After this, there were no differences in intake. Milk yield was significantly higher in the ewes that had the highest level of nutrition during pregnancy (Table 2). This was the result of the larger number of mammary secretory cells but probably was due to the larger availability of body reserves during lactation also.

Mammary gland development can also be stimulated by hormonal treatments. For example, sheep treated with prostaglandin and then with pregnant mare serum gonadotropin at the end of the diestrus had larger mammary gland and higher number of secretory cells than untreated animals. This resulted in a dramatically higher (+59%) milk yield in the first 4 months of lactation compared to control ewes (Manalu et al., 2000).

Unfortunately neither of the two studies cited above measured milk yield after the first 4 months of lactation. Thus, possible effects on persistency could not be evaluated.

Proper nutrition during pregnancy also influences milk yield because it allows the accumulation of sufficient body fat and protein reserves, which can be mobilized in the first months of lactation. Even when sheep are fed high quality diets, in the first months of lactation a negative energy balance is inevitable. This occurs because after lambing, milk production and, consequently, the energy requirements of the animals grow more rapidly than the intake of energy from the diet. This situation is worsened when the first months of lactation coincide with low feed availability (e.g. winter lambing season). In the first two months sheep produce a large part of their milk by mobilizing their body fat and protein reserves. Caja and Bocquier (1998) reported that at the beginning of the lactation almost 50% of milk energy came from the mobilization of sheep body reserves.

Thus, it is very important that sheep have sufficient body reserves at the beginning of lactation. Robinson (1987b) has clearly shown how body fat reserves and energy intake are of great importance in this period. In his experiments, milk production of sheep with very high energy intake was almost unrelated to body reserves. However, when the energy intake was lower, milk production was greatly influenced by sheep body fat reserves. The thinner the sheep, the less milk that was produced. Given that the highest energy intake reported by Robinson (1987b) is hard to achieve in grazing sheep, because concentrates are supplied separately from forage, and low forage to concentrate ratios are not feasible, it becomes obvious that sufficient fat reserves are essential for high milk production in the first months of lactation.

Body reserve losses can be considered normal as long as they are not excessive or too fast. In BCS terms, the INRA (1989) suggests an optimal body condition score (**BCS**) at lambing between 3.25 to 3.5, which may fall to a minimum of 2.0 to 2.5 in the 6<sup>th</sup> to 8<sup>th</sup> week of lactation. The ewes should not lose more than 1 BCS in six weeks. Too high energy deficits cause reduction of milk production (Caja and Bocquier, 1998), with increased risks of ketosis and a negative effect on milk yield in the second part of the lactation.

Lactating ewes with highly negative energy balance tend to reduce their milk production more markedly than cows do. Indeed, while in cows genetic selection has resulted in dairy cows having a hormonal status that encourages milk production even with high fat mobilization, in dairy sheep there has not been so much genetic improvement, and ancestral characteristics designed to protect the life of the animal are often more evident. Even in cattle, animals of breeds not selected for milk production decrease their milk yield more rapidly when they are underfed compared to dairy cattle (Preston and Leng, 1986; cited by Chilliard, 1992).

However, ewes that are too fat at lambing usually have low milk production in the first months of lactation. Stern et al. (1978) observed that ewes overfed during pregnancy had markedly lower DM intake (-21%) and milk yield than ewes properly fed during pregnancy. This happened because the excessive quantity of visceral fat compressed the rumen and reduced feed intake and nutrient availability.

### **Monitoring sheep energy balance**

During the first months of lactation it is important to monitor the energy balance of the ewes and to avoid it becoming too negative. This is particularly important in sheep because the high

genetic variability within breed causes large variability in milk yield as well. An example is given in Figure 14, where the distribution of milk yields in a flock of Sarda ewes in the 4<sup>th</sup> month of lactation is represented. This high variability implies that for a proper feeding management the flock of a farm should be subdivided in subgroups based on the milk yield of the ewes. This should be done to avoid underfeeding of high productive animals and overfeeding of the least productive animals. Group feeding strategies have been studied by Caja and Bocquier (1988) and by Bocquier et al. (1995).



Figure 14 - Distribution of milk yields within a flock of lactating Sarda ewes in the 4<sup>th</sup> month of lactation.

One tool that can be used in the field to monitor the energy balance of the ewes is to assess their BCS. This method is fairly accurate when the mean BCS variation of a flock needs to be monitored. However, it cannot be easily applied to identify those animals within the flock that are losing weight too quickly.

Another possible method involves the measurement of the variations of milk fat concentration during lactation. Sheep energy balance (**EB**) is probably the factor that has the largest effect on milk fat concentration. Indeed, when body fat mobilization is high (usually at beginning of the lactation), the effect is an increase of the blood concentration of long chain fatty acids derived from body fat triglycerides; part of these fatty acids are used by the mammary gland to produce milk fat, whose concentration increases. Another effect is an increase in the concentration of long chain fatty acids in milk fat. Bocquier and Caja (1993; 2001) found a close negative relationship between EB and milk fat concentration, in sheep of different dairy and non-dairy breeds with milk yields ranging between 0.65 and 3.5 l/d:

$$\text{milk fat concentration (weight/volume)} = 6.84 - 1.22 \text{ EB (UFL/d)}; r^2 = 0.76$$

where UFL = 1.7 Mcal of NEL<sub>1M</sub>.

Recently, Cannas and Avondo (2002) observed a similar relationship in grazing Comisana dairy ewes with milk yields of between 0.65-1.60 kg/d. This suggests that the relationship between milk fat concentration and EB is not markedly affected by the breed of the ewes. Cannas and Avondo (2002) subdivided their database into 4 classes, which were based on the milk yield of the ewes (< 400 g/d, n = 63; 400-799 g/d, n = 260; 800-1199 g/d, n = 97; 1200-1600 g/d, n = 20) and noted that, going from the highest to the lowest milk yield class, this relationship became weaker (Figure 15). It is clear that the relationship between milk fat concentration and EB is especially important for ewes with high milk yield, while it is very weak for animals with low milk yield.

In any case, as EB varied, the range of variation in milk fat concentration found by Bocquier and Caja (1993; 2001) and by Cannas and Avondo (2002) in sheep was much larger than that observed in dairy cows (e.g. Grieve et al., 1986), suggesting a more important contribution of FA derived from body fat mobilization in sheep than in cows.

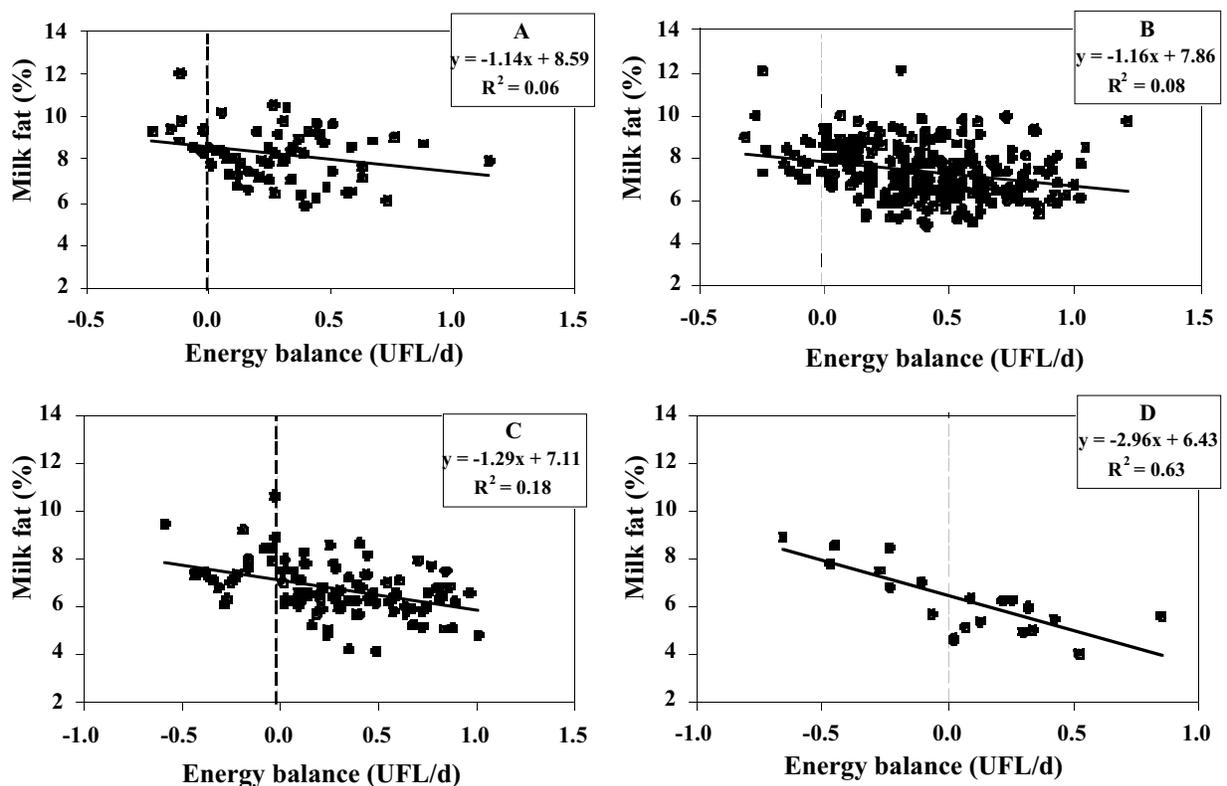


Figure 15 - Relationship between milk fat concentration and energy balance of grazing Comisana ewes divided into 4 milk yield production classes: A = < 400 g/d, n = 63; 400-799 g/d, n = 260; 800-1199 g/d, n = 97; 1200-1600 g/d, n = 20. The dotted line represents, in each plot, the limit between negative and positive energy balance (adapted, from Cannas and Avondo 2002). All the regressions were significant for  $P < 0.01$ , except for the regression A for which  $P < 0.1$ .

The close relationship between EB and milk fat content suggests that milk fat concentration can be used to predict the EB of the animals. Similarly, in dairy cows the variations in milk fat concentration during lactation were used to identify across-herd differences in EB and to identify potential problematic cows within the herd (de Vries and Veerkamp, 2000), such as animals that are losing body fat reserves too quickly and are probably in sub-ketosis.

It seems, then, that milk fat concentration and its variations can be used as an nutritional indicator in the field, even though more research is needed to increase its accuracy.

### **Nutrition during the first part of the lactation**

In sheep, the effect of dietary energy concentration seems to be markedly affected by the stage of lactation.

During the first part of lactation, energy rich diets generally gave much higher milk yield than medium-low energy concentration diets (Susin et al., 1995; Abdel-Rahman and Mehaia, 1996; Al Jassim et al., 1999; Caja and Bocquier, 2000; Alexandre et al., 2001). For example, high roughage diets (60:40 forage to concentrate) gave much lower milk yield than low roughage diets (20:80 forage to concentrate) in Finnsheep ewes in the first weeks of lactation (Brown and Hogue, 1985) (Table 3).

While the ewes fed rich energy diets increased their milk yield in the first 7 weeks of lactation, the opposite occurred in the ewes fed high fiber diets.

Table 3 - Effect of the forage to concentrate ratio on milk yield (kg/d) in the first weeks of lactation of Finn sheep ewes (Brown and Hogue, 1985).

	<b>Forage to concentrate ratio</b>	
	<b>60:40</b>	<b>20:80</b>
<i>Week 2</i>	1.45	1.54
<i>Week 4</i>	1.15 <sup>a</sup>	1.78 <sup>b</sup>
<i>Week 7</i>	1.04 <sup>a</sup>	2.71 <sup>b</sup>
<i>Mean</i>	1.21 <sup>A</sup>	2.11 <sup>B</sup>

<sup>a, b</sup> P < 0.05    <sup>A, B</sup> P < 0.01

Under-nutrition in the first part of lactation generally results in low and delayed peaks of milk yield or the absence of the lactation peak (continuously declining curves) (Figure 2). Under-nutrition in this stage, especially when it is prolonged, reduces the number of secretory cells permanently. Despite this, re-feeding can induce higher milk yield than observed during the under-nutrition period (Caja and Bocquier, 2000). This probably happens because the secretory cells that are still active increase their synthetic activity.

### **Nutrition during the intermediate and final part of the lactation**

In nutritional terms an exact definition of the moment of transition from initial lactation to full lactation should be based on whether or not the animals have a negative (first phase) or positive (second phase) energy balance rather than on the month of

lactation. When the ewes are well fed, this transition can occur very early (during the first two months of lactation). However, when the nutrition of the ewes is not adequate the transition is postponed. For example, in the Mediterranean region it occurs after the beginning of the Spring, when the ewes are in their 3<sup>rd</sup>-4<sup>th</sup> month of lactation and have their peak of lactation.

In contrast with the first part of the lactation, the utilization of diets rich in sugars and starch in this stage gives controversial results. There are cases in which the utilization of concentrates rich in starch and protein markedly improves milk yield even in late lactation. This usually happens when the diet is markedly unbalanced or when feed intake is low, such as when the ewes are fed on mature or scarce pastures. As an example, we report an experiment carried out at the end of the lactation in Sarda sheep grazing on cereal stubbles, which in the Mediterranean areas are usually very rich in fiber (60-70% of NDF, DM basis) and low in protein (6%-8%, DM basis). Supplementing the diet with concentrates rich in starch and protein increased milk yield and lactation persistency (Figure 16).

When the diets are sufficiently well balanced, the effects of nutritional treatments in mid-late lactation are often more evident on BW variations (usually positive) than on milk yield (often unchanged or reduced) (Bocquier and Caja, 1993).

An example is given by the results of an experiment carried out during the 5<sup>th</sup> and the 6<sup>th</sup> month of lactation of Sarda ewes (Bomboi et al., 2002) (Tables 4 and 5). During the preliminary period the ewes were fed a TMR diet with a 75:25 forage to concentrate ratio, made of chopped alfalfa and concentrates (Table 4).

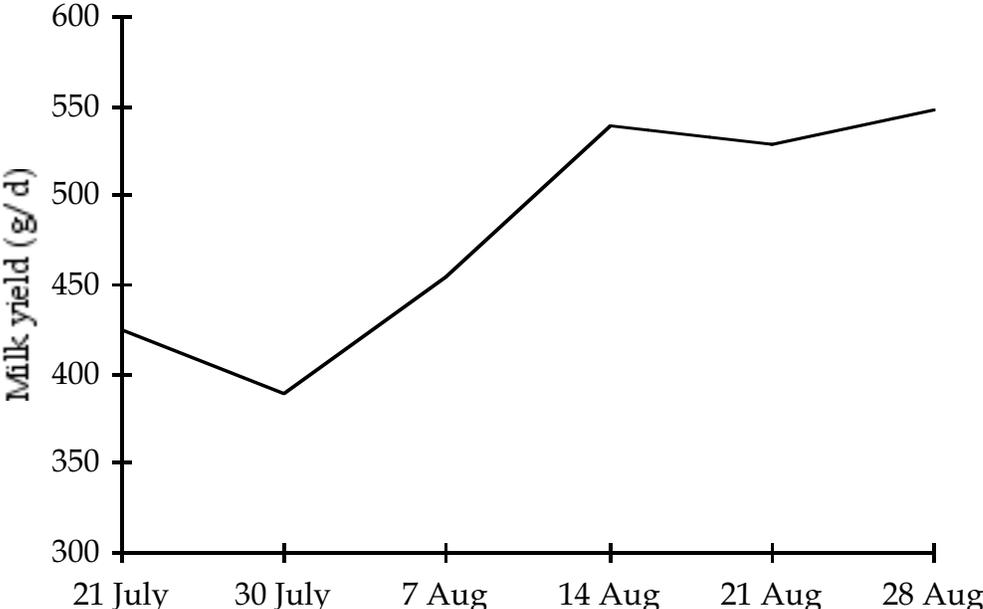


Figure 16 – Positive effects of the supplementation with concentrates rich in energy and proteins on milk yield of dairy ewes in late lactation (8<sup>th</sup> - 9<sup>th</sup> month) fed on stubble (Pulina et al., 1993b).

During the 7 weeks of the experimental period, the ewes were subdivided in three groups. One group kept the preliminary period diet, another was fed a diet rich in forage (90:10 forage to concentrate ratio) and the third one was fed a diet rich in concentrates (60:40 forage to concentrate ratio). The results (Table 5) showed that DM intake was the lowest with the 90:10 diet, and energy intake increased as the forage to concentrate ratio decreased. Milk yield was not affected by the feeding treatments, while BW significantly increased as the content of concentrate in the diet increased. This experiment suggests that the extra energy received by the ewes when the percentage of concentrates in the diet increased (from 25% to 40% of the diet) was only used to accumulate body reserves. By contrast, when the forage content increased (from 75% to 90% of the diet), despite the lower intake of energy, milk yield was similar to that of the 75:25 group, suggesting that a larger proportion of dietary energy was used for milk production.

Comparing Greek dairy ewes fed diets with two very low forage to concentrate ratios (40:60 vs. 20:80), which also differed in the fiber content of the concentrates, during the 4<sup>th</sup> and the 5<sup>th</sup> month of lactation, Zervas et al. (1999) observed a significant but small increase in milk yield for the diets with the lowest ratio. However, these diets were quite low in CP concentration. In addition, there were large differences in dietary CP content among some of the treatments. This may have affected the results. The same comment can be made about the experiment of Goodchild et al. (1999), in which Awassi ewes were fed diets differing in forage to concentrate ratio but with large differences in dietary CP concentration. Since dietary protein can markedly affect milk yield (e.g. Figure 17) and DM intake (Van Soest, 1994), comparisons should always be made with isonitrogenous diets.

Table 4 - Chemical composition and ingredients of an experiment in which lactating Sarda ewes in mid-lactation were fed diets differing in the forage to concentrate ratio (Bomboi et al., 2002).

	<b>FORAGE TO CONCENTRATE RATIO</b>		
	<b>90:10</b>	<b>75:25</b>	<b>60:40</b>
<b><i>Ingredients (g/kg of DM)</i></b>			
Chopped alfalfa hay	900	750	600
Rolled barley grain	37.5	94	150
Rolled corn grain	37.5	94	150
Soybean meal	22	55	88
Minerals + vitamins	3	7	12
<b><i>Composition</i></b>			
CP (% of DM)	17.3	17.5	17.6
NDF (% of DM)	35.2	31.1	27.1
NFC <sup>1</sup> (% of DM)	37.4	41.8	46.3
NEL (Mcal/kg of DM)	1.425	1.512	1.599

<sup>1</sup> NFC = non structural carbohydrates, calculated as: 100 - (NDF-NDF<sub>IP</sub>) - CP - EE - ash.

Table 5 – Main results of an experiment in which lactating Sarda ewes in mid lactation were fed diets differing in the forage to concentrate ratio (Bomboi et al., 2002). Covariate adjusted means.

	Forage to concentrate ratio		
	90:10	75:25	60:40
DM intake (g/d)	2147 <sup>A</sup>	2262 <sup>B</sup>	2213 <sup>A<sup>B</sup></sup>
NEL intake (Mcal/d)	3.064 <sup>D</sup>	3.417 <sup>E</sup>	3.538 <sup>E</sup>
Milk yield (g/d)	1114	1110	1134
Fat (%)	5.53 <sup>AB</sup>	5.30 <sup>A</sup>	5.70 <sup>B</sup>
Protein (%)	5.62 <sup>A</sup>	5.47 <sup>B</sup>	5.82 <sup>C</sup>
Body weight (kg)	45.98 <sup>D</sup>	46.85 <sup>E</sup>	47.91 <sup>F</sup>
Glucose (mg/dl)	53.3 <sup>D</sup>	57.4 <sup>E</sup>	60.0 <sup>E</sup>
Insulin (μU/ml)	26.6	26.7	27.2
NEFA (μEq/l)	165 <sup>A</sup>	151 <sup>A</sup>	107 <sup>B</sup>
Somatotropin (ng/ml)	2.54 <sup>a</sup>	1.93 <sup>b</sup>	1.52 <sup>b</sup>

<sup>a, b, c</sup> = P < 0.07; <sup>A, B, C</sup> = P < 0.05; <sup>D, E, F</sup> = P < 0.001

In some experiments higher milk yield was observed using diets with low nonstructural carbohydrates and high fiber concentration compared to richer diets.

East Friesian ewes from the 5<sup>th</sup> to the 7<sup>th</sup> month of lactation were fed TMR diets differing in the concentration of starch and sugars (NSC) in the concentrates (Cavani et al., 1990). In one case, the concentrate consisted of a pelleted feed containing 35% of NSC, while in the other case a mixture of pelleted feed, soybean hulls and distillers of cereals containing 20% of NSC was used (Table 6). On the whole, one diet had 20.7% (DM basis) NSC, the other one 15.7% (DM basis) (Table 6). The results of the experiment showed that the two groups of ewes had a similar daily intake of energy. However, the group fed the diet with the lower NSC concentration had a significantly higher milk yield, milk fat concentration and milk fat corrected milk yield when compared to ewes fed diets with the higher NSC concentration, which in turn had higher positive BW variations (Table 7).

In another experiment, lactating Sarda ewes in mid-lactation (from the 4<sup>th</sup> to the 6<sup>th</sup> month), were fed pelleted diets with increasing concentrations of CP (from 14% to 21% CP; Table 8) at two levels of energy (HE, high energy = 1.65 Mcal/NE<sub>L</sub> kg DM; LE, low energy = 1.55 Mcal/NE<sub>L</sub> kg DM) and non fiber carbohydrates (NFC: sugars, starch, and pectins) concentration (Table 8) (Cannas et al., 1998). The two energy levels differed in terms of ingredients because the cereal grains used in the HE were substituted by beet pulps and soybean hulls.

Table 6 - Comparison of two levels of sugars and starch in TMR diets for East Friesian lactating ewes: characteristics of the diets (Cavani et al., 1990).

	<b>Sugar + Starch</b>	
	<b>15.7%</b>	<b>20.7%</b>
<b><i>Ingredients</i></b>		
Corn sil.+ beet pulp sil.+ meadow hay (% of DM)	64.9	64.9
Pelleted concentrate (% of DM)	19.1	35.1
Soy bean hulls (% of DM)	11.2	0
Distillers of cereals (% of DM)	4.8	0
<b><i>Composition</i></b>		
CP (% of DM)	13.9	13.6
Starch + sugars (% of DM)	15.7	20.7
ADF (% of DM)	34.4	28.5
NEL (Mcal/kg DM)	1.57	1.57

Table 7 - Comparison of two levels of sugars and starch in TMR diets for Friesian lactating ewes: main results (Cavani et al., 1990).

	<b>Sugar + Starch</b>	
	<b>15.7%</b>	<b>20.7%</b>
DIM at the beginning of the trial (d)	122	121
Length of the trial (d)	77	77
DMI (kg/d)	2610	2490
NEL intake (Mcal /d)	4.1	3.9
Initial BW (kg)	79.3	81.7
BW variations (g/d)	28.7 <sup>a</sup>	49.2 <sup>b</sup>
Milk yield (g/d)	1209 <sup>A</sup>	1107 <sup>B</sup>
6.5% fat corrected milk yield (g/d)	1186 <sup>A</sup>	1043 <sup>B</sup>
Milk fat content (%)	6.39 <sup>a</sup>	6.15 <sup>b</sup>
Milk fat yield (g/d)	75.8 <sup>A</sup>	65.8 <sup>B</sup>
Milk protein content (%)	4.86	4.94
Milk protein yield (g/d)	58.2 <sup>a</sup>	53.9 <sup>b</sup>

A, B: P< 0.01 a, b: P< 0.05

Table 8 - Composition of the diets of an experiment in which lactating Sarda ewes were fed diets differing in protein and energy concentration (Cannas et al., 1998)..

CP, % of DM	HE <sup>1</sup>				LE <sup>2</sup>			
	14.2	16.6	18.8	21.2	13.9	16.3	18.6	21.1
<b>Ingredients (% of DM)</b>								
Dehydrated alfalfa	30.2	30.2	30.2	30.2	30.0	33.4	36.6	40.0
Beet pulp	13.2	14.1	15.0	16.0	39.0	32.3	26.0	19.3
Soybean hulls	14.6	14.8	14.9	15.1	25.0	25.0	25.0	25.0
Corn grain	19.7	18.0	16.4	14.8	3.9	2.6	1.3	
Wheat grain	20.4	15.3	10.6	5.5				
Fish meal		0.7	1.3	2.0		0.7	1.3	2.0
Soybean meal		4.5	8.6	13.1		3.4	6.7	10.1
Corn gluten meal		0.7	1.3	2.0		0.7	1.3	2.0
Miner., vitam., ligands	1.9	1.7	1.6	1.4	2.2	1.9	1.7	1.5

<sup>1</sup> HE = high energy (1.65 Mcal/NE<sub>L</sub> kg DM).

<sup>2</sup> LE = low energy (1.55 Mcal/NE<sub>L</sub> kg DM).

The ewes fed the LE diets had, on average, higher DM intake but similar daily energy intake than the ewes fed the HE diets (Table 9), suggesting that fiber particle size did not limit DM intake. The ewes fed the LE diets had significantly higher milk yield and milk fat content compared to the ewes fed HE diets, while milk protein concentration did not differ between energy levels (Table 9). Milk yield was markedly affected by the protein concentration of the diets in both groups. For each CP level it was higher in LE than HE diets (Table 9 and Figure 17).

Another experiment was carried out during the 4th month of lactation on Sarda lactating ewes to compare diets with different NFC concentration (35% vs. 24%, DM basis) (Molle G., Cannas A., Bomboi G., unpublished). The diets were made up of 350 g/d of chopped dehydrated alfalfa and pellets ad libitum. The pellets differed in their ingredients (mostly because the cereal grains used in the NFC 35 diet were substituted by soybean hulls) and chemical composition (Table 10). The ewes fed the diets with the lowest NFC concentration (NFC 24) had higher DM intake but similar daily energy intake than the ewes fed the NFC 35 diets (Table 11).

Table 9 - Relationship between dietary crude protein and energy concentration and intake and milk production of Sarda sheep fed pelleted diets (Cannas et al., 1998).

Energy level <sup>1</sup>	Dietary Composition (% of DM)				Intake		Milk		
	CP	NFC <sup>2</sup>	NSC <sup>3</sup>	NDF	DM kg/d	NEL Mcal/d	Yield kg/d	Fat %	Protein %
HE	21.2	24.8	20.7	47.3	2.12	3.49	1.34	5.6	5.4
HE	18.8	27.4	24.1	48.0	2.33	3.84	1.34	5.4	5.3
HE	16.6	29.9	27.3	48.7	2.34	3.87	1.20	5.7	5.4
HE	14.2	32.5	30.7	49.4	2.02	3.35	1.16	5.7	5.7
LE	21.1	37.4	15.7	37.7	2.47	3.83	1.48	5.9	5.2
LE	18.6	38.9	15.2	37.9	2.54	3.94	1.50	5.7	5.3
LE	16.3	40.3	14.7	38.0	2.38	3.69	1.43	5.7	5.4
LE	13.9	41.8	14.3	38.1	2.18	3.37	1.26	6.0	5.5
HE Mean	17.7	28.7	25.7	48.4	2.20 <sup>m</sup>	3.64	1.26 <sup>M</sup>	5.58 <sup>M</sup>	5.45
LE Mean	17.5	39.6	15.0	37.9	2.39 <sup>n</sup>	3.71	1.42 <sup>N</sup>	5.82 <sup>N</sup>	5.36

<sup>m, n</sup> = P < 0.06    <sup>M, N</sup> = P < 0.005    <sup>1</sup> HE = High Energy, 1.65 Mcal of EN<sub>L</sub>/kg DM; LE = Low Energy, 1.55 Mcal of EN<sub>L</sub>/kg DM.    <sup>2</sup> NFC = non structural carbohydrates, calculated as: 100 - (NDF - NDF<sub>IP</sub>) - CP - EE - ash.    <sup>3</sup> NSC = starch and sugars.

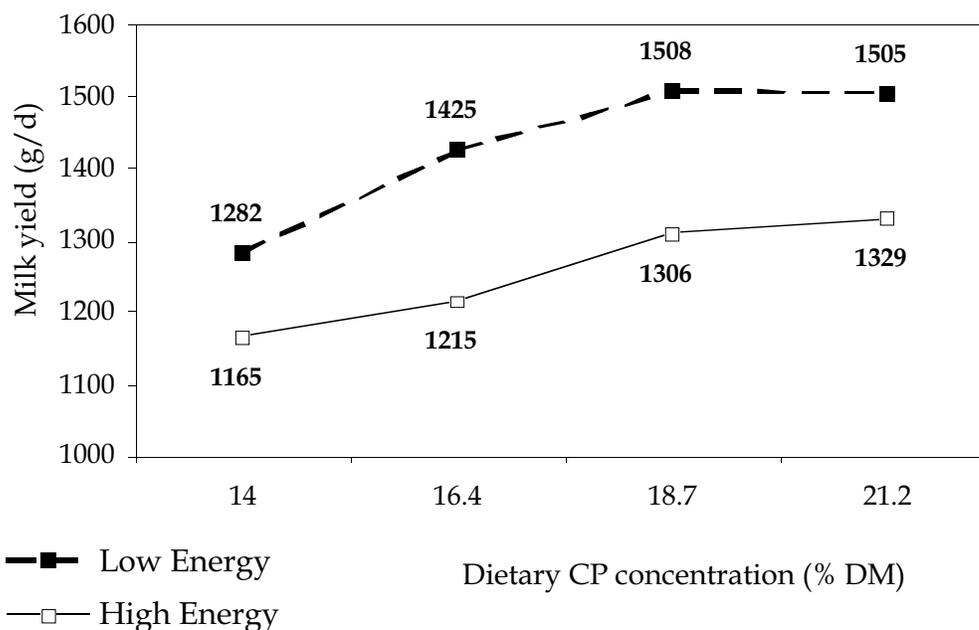


Figure 17 - Relationships between CP content of the diet and milk yield in two groups of housed lactating ewes fed either high energy (HE, 1.65 Mcal of EN<sub>L</sub>/kg DM) or low energy (LE, 1.55 Mcal of EN<sub>L</sub>/kg DM) pelleted diets. Milk yield in the preliminary period was 1.28 kg/d for the HE group and 1.22 kg/d for the LE group (Cannas et al., 1998).

This suggests that DMI was not limited by the high NDF content (51.2%) of NFC 24 diets, probably because of the small particle size of the fiber included in the pellets, but was regulated by requirements. The ewes fed the NFC 24 diet had significantly higher milk yield, lower milk protein content and similar milk fat content when compared to the ewes fed NFC 35 diets. BW variations and energy balance were slightly higher in the NFC 35 diet, even though these differences were not statistically significant.

Table 10 - Ingredients and chemical composition of two pellets differing in their NFC concentration and fed *ad libitum* to lactating Sarda ewes (Molle G., Cannas A., Bomboi G., unpublished).

	Pellet for diet NFC 35	Pellet for diet NFC 24
<b>Ingredients (% of DM)</b>		
Cracked corn grain	16.0	
Wheat grain	15.4	
Dehydrated alfalfa	29.5	29.5
Beet pulp	10.2	10.2
Soybean hulls	9.2	43.0
Soybean meal 44%	16.6	14.5
Minerals	0.8	0.8
Ligands	2.3	2.0
<b>Composition (% DM)</b>		
CP (% of DM)	20.2	19.5
NDF (% of DM)	36.7	51.2
NFC <sup>2</sup> (% of DM)	36.1	23.2
Starch (% of DM)	26.2	6.9

<sup>2</sup> NFC = non-structural carbohydrates, calculated as:  $100 - (\text{NDF} - \text{NDF}_{\text{IP}}) - \text{CP} - \text{EE} - \text{ash}$ .

In summary, these experiments suggest that during mid-late lactation the effects on milk of diets differing in their forage to concentrate ratio (and thus in their energy, NDF and NFC concentration) are not as clear as in the first part of the lactation. When the ewes are underfed, with shortage of energy, protein or both, the utilization of diets rich in concentrates improves milk yield. However, when the ewes are well fed, the utilization of large doses of concentrates rarely improves milk yield and often decreases it. It seems that when diets with different NFC concentration are compared, if the daily energy intake is similar between NFC levels, diets with low NFC concentration induce higher milk yield (experiments reported in the Tables 6-11). On the other hand, when the physical control of the diets keeps the intake of energy in low NFC diets lower than that of high NFC diets (such as in the experiment described in Table 4 and 5), milk yield is not affected by the utilization of diets rich in NFC, with energy partition favoring body reserve accumulation.

Practical reference values for dietary energy, NDF and NFC concentration for lactating ewes were reported by Cannas (2002b).

Table 11 - Main results of an experiment in which two pelleted feeds differing in their NFC concentration were fed *ad libitum* to lactating Sarda ewes together with 350 g/d of chopped dehydrated alfalfa (Molle G., Cannas A., Bomboi G.; unpublished).

	DIET		P<
	NFC 35	NFC 24	
BW (kg)	42.75	42.07	NS
DM intake <sup>1</sup>	2593	2943	0.005
NEL intake (Mcal/d)	4.21	4.25	NS
Milk yield (kg/d)	1825	2098	0.01
Milk fat (%)	5.06	5.19	NS
Milk protein (%)	4.75	4.45	0.003
Energy balance <sup>2</sup> (Mcal/d)	+1.683	+1.481	NS
BW variations (kg/d)	0.159	0.148	NS
Glucose (mg/dl)	62.1	59.8	0.07
Insulin ( $\mu$ U/ml)	14.6	22.6	0.002
Prolactin (ng/ml)	452	437	NS
Growth hormone (ng/ml)	3.36	5.20	0.02
Cortisol ( $\mu$ g/dl)	0.554	0.555	NS

<sup>1</sup> the DM intake of the dehydrated chopped alfalfa is included in the total, which was 284 g/d and 301 g/d for the NFC 35 and NFC 24 diets, respectively;

<sup>2</sup> NEL daily intake - energy requirements for maintenance and milk production.

### Interpretation of the experiments and nutritional implications

The experiments so far reported suggest that the effects of dietary forage to concentrate ratios (and thus dietary NDF and NFC) on milk yield and body reserve accumulation vary depending on the stage of lactation. During early lactation, large amounts of grains (NFC up to 35-40%) seem to help ewes with negative energy balance to reduce the deficit of energy and to produce more milk, while later on large amounts of grains (and thus of NFC) seem to be detrimental, because they stimulate fattening and not milk synthesis.

The reason for this difference is probably associated to variations of the hormonal status during lactation. The most important hormone implicated in the partitioning of nutrient between milk production and body reserve is the growth hormone (**GH**). When its blood concentration is high, dietary energy is used preferentially for milk production, while when it is low, body reserve accumulation is favored. During the first months of lactation, in ruminants GH concentration is usually high and insulin, which by itself stimulates uptake of glucose by peripheral tissues, is low. In addition, GH reduces the responsiveness of peripheral tissues to insulin (Rose and Obara, 1996). In this situation, there is a preferential utilization of glucose and lipogenic precursors by the mammary gland (Vernon, 1989). When lactation progresses, blood GH declines, insulin concentration increases and body fat tissues become very responsive to insulin action. This means that any increase in blood glucose stimulates the action of insulin, which favors glucose utilization for anabolic processes by peripheral tissues but not by the mammary gland, which is not responsive to insulin. The effect is a reduction of the glucose available for the mammary gland, with subsequent reduction of milk yield.

In sheep the action of insulin is probably even more important than in dairy cows, because blood GH concentrations are quite low for the whole lactation (Figure 18). This difference between sheep and dairy cows is the result of the high genetic selection that dairy cows have been subjected to. Genetically superior cows have higher and more persistent blood concentrations of GH than inferior cows (Peel and Bauman, 1987; Sorensen et al., 1998). Injection of GH in ruminants has positive effects on milk yield and lactation persistency. Dairy cows treated with GH behave as genetically superior cows do and tend to use the nutrients more for milk production than for body fat deposition (Peel and Bauman, 1987). GH injection in dairy cows increases milk yield by 10-25% and is more effective when used in mid-late lactation. In sheep GH injections are effective even in the first half of lactation (34% more milk between the 3<sup>rd</sup> and the 8<sup>th</sup> week of lactation; Fernandez et al., 1995b) and induce much stronger effects (Baldi, 1999) than in dairy cows, probably because of the lower natural GH blood levels of sheep. In some cases, the effects are really dramatic. For example, Assaf ewes in the third month of lactation increased their milk yield by 55% (from 1.91 to 2.97 liters/d), when compared to control ewes, after the injection of 0.1 mg/kg of BW of GH (Leibovich et al., 2001).

In summary, during the first part of the lactation the GH levels are high, insulin action is limited and the utilization of diets rich in concentrates increases blood glucose, which is preferentially used by the mammary gland for milk secretion.

In mid-late lactation, GH is low and insulin is very active. When diets rich in concentrates are used, propionate production in the rumen increases. Propionate is used by the liver to produce glucose, which in turn stimulates insulin action, with reduction of blood glucose available for mammary gland syntheses.

The beneficial effects of forage-rich diets in mid-late lactation can be explained by the fact that they stimulate rumen acetate production, which cannot be used to produce glucose and does not stimulate insulin action. In addition, forage-rich diets are eaten slowly, reducing the peaks of production of propionate and the insulin response (Takahashi et al., 1989). Acetate is both a metabolic fuel, and can in part substitute glucose in this, and a precursor of fat. Lactating ewes probably have a higher acetate requirement than lactating cows, because their milk has much higher fat to lactose ratio. Pethick and Lindsay (1982) found that acetate uptake by the lactating ewe udder represents a greater drain on acetate supply than the udder of dairy cows. In addition, in two of our experiments the diets with the lowest NFC concentration had significantly higher GH concentrations and lower glucose concentration (Tables 5 and 11). Indeed, hypoglycemia and underfeeding tend to increase blood GH concentrations (Breier, 1999; Hatfield et al., 1999). As discussed in paragraph 2, GH retards the involution of mammary secretory cells. Thus, the utilization of low NFC diets may affect nutrient partitioning positively and reduce involution of the mammary gland, as long as the energy intake is sufficiently high.

In practice, it is not easy to achieve high energy intake using diets low in NFC and rich in fiber. This can be done only if the fiber of the diet is highly digestible and does not impose physical constraints on intake. These physical constraints can be reduced by chopping or grinding the forage. Sheep can safely use diets with very low particle size, with positive effects on feed intake and milk yield (Rossi et al., 1991; Cannas, 1995; Cannas, 2002b). The high digestibility of fiber is a characteristic of young forages and of some feed by-products, such as soybean hulls and beet pulps.

The effect of forage quality on milk yield and persistency was evident when ryegrass and alfalfa pastures were compared (Figure 13; Bomboi G., Cannas A., Molle G.). Alfalfa typically has lower NDF concentration and higher fiber degradability than ryegrass; this often results in high intake and milk yield (Van Soest, 1994). Pasture management and characteristics affecting feed intake and milk yield in dairy ewes are discussed elsewhere (Cannas, 1996; Avondo and Lutri, 2002; Cannas, 2002b, Molle et al., 2002).

Soybean hulls and beet pulps are rich in highly digestible NDF and in pectins, which have high degradation rates but do not stimulate lactic bacteria (Van Soest, 1994). Indeed, the diets of the experiments in which high fiber intake induced high milk yield are all based on beet pulps and soybean hulls. Positive effects of soybean hulls on sheep milk yield were also reported by Zervas et al. (1998), in a trial in which Greek dairy ewes were fed 800 g/d of grass hay and 1200 g/d of three different concentrate formulations. One had 60% of ground corn as the main ingredient, in another corn was replaced by equal percentages of soybean hulls, in the third one the concentrate with soybean hulls included soybean oil as well. The latter treatment will be discussed in the section on fat supplementation. The ewes that used the concentrate with soybean hulls produced slightly more milk than the ewes fed corn-rich concentrate and had significantly higher milk fat concentration.

As a result, they produced significantly higher amounts of 6% fat corrected milk (936 vs. 806 g/d for soybean hulls concentrate vs. corn concentrate, respectively;  $P < 0.001$ ). The stage of lactation during which the experiment was carried out was not reported. However, the fairly low milk yield and the positive BW variations observed during the experiment suggest that it was carried out during mid-late lactation.

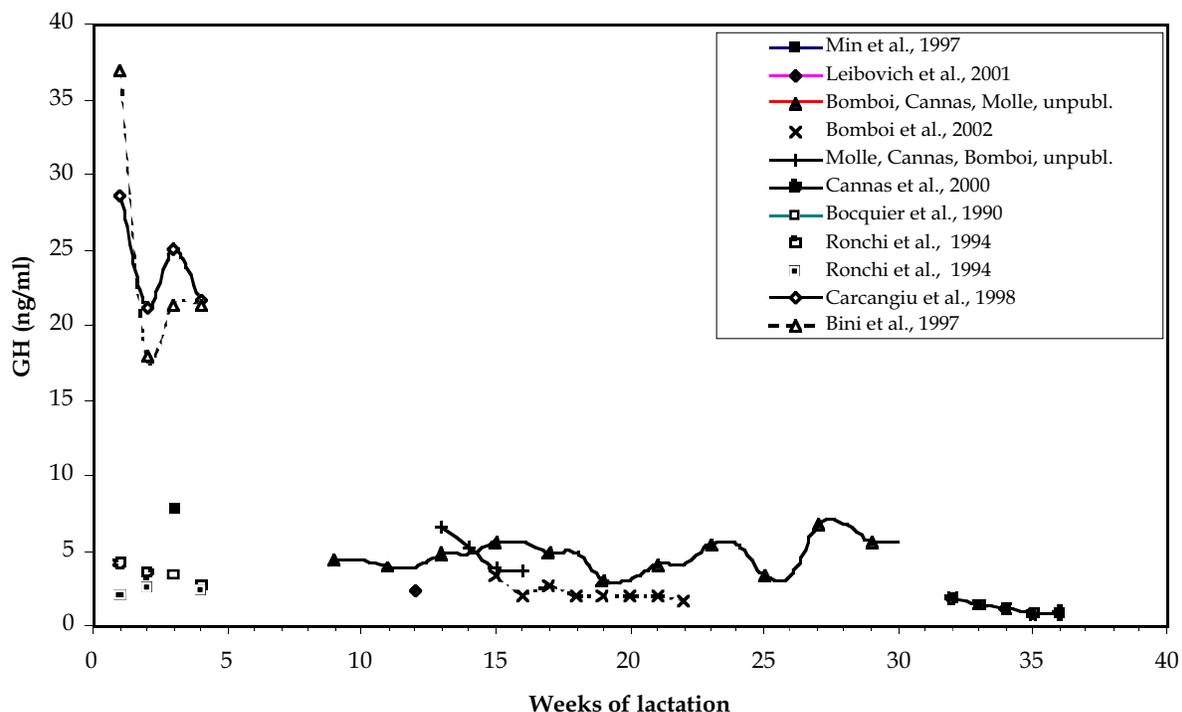


Figure 18 - Growth hormone concentration in lactating ewes during the lactation

## EFFECTS OF DIETARY FAT ON LACTATION PERSISTENCY

Dietary lipid supplementation has been used in diets for ruminants to increase dietary energy concentration and efficiency and, as a consequence, to increase milk yield in high producing animals. It has also been used to increase milk fat content and to modify the milk fatty acid profile. Here we will consider only the use of fat to increase milk yield and lactation persistency in sheep.

The effects of fat supplementation in sheep were examined by Chilliard and Bocquier (1993), Caja and Bocquier (2000) and Bocquier and Caja (2001). After reviewing the scientific literature, they concluded that fat supplementation increased milk yield in dairy cows but not in sheep and in goats and always increased milk fat content in sheep and goats but not always in dairy cows. No effects of calcium soaps of fatty acids (CSFA) on milk yield were also reported by McKusick et al. (1999b). However, these conclusions contrast with some other published experiments.

In lactating Sarda sheep, Rossi et al. (1991) compared complete pelleted diets with or without 4% CSFA. Dietary CP was close to 18% of DM. The ewes were fed hay and concentrates during a two-week preliminary period. They were then fed solely the experimental pelleted diets from the 10<sup>th</sup> to the 30<sup>th</sup> week of lactation. The utilization of the pelleted diets markedly increased milk yield in both groups, without differences between them until the end of the 6<sup>th</sup> experimental week (16<sup>th</sup> week of lactation) (Figure 19). After this, the milk yield of the two groups started to differ, with higher milk yield and lactation persistency in the ewes fed the pelleted diet added with CSFA. This difference was maintained until the end of the experiment. During the 20 experimental weeks the group with CSFA produced significantly more milk than the group without CSFA (188 kg vs. 168 kg). Milk fat content was also increased by the utilization of CSFA, but the effect was much faster than in the case of milk yield (Figure 20). Milk protein content was not affected by CSFA.

In another trial, Assaf ewes were fed diets with CSFA added (5.6% of dietary DM) from lambing to 90 days of lactation (Sklan, 1992). The main effects of CSFA addition were a significant increase in milk yield (1.36 vs. 1.59 kg/d for control and CSFA, respectively), with a concomitant increase in milk fat and reduction in milk protein compared to the control diet. The effects of CSFA were large until the end of the second month of lactation, then they quickly decreased.

Significant increases in milk yield and lactation persistency for the whole length of the experiment (from lambing to 140 days of lactation) were also observed by Laudadio et al. (2002) on Comisana ewes whose diet was supplemented with CSFA.

The positive effects of the addition of lipids were also observed when adding 5% soybean oil to the concentrates in the study of Zervas et al., (1998) previously reported when discussing soybean hulls effects. The addition of soybean oil significantly increased milk yield (947 g/d vs. 733 g/d) but significantly decreased milk fat and milk protein concentration compared to the same pelleted concentrate without oil. Similarly, Mele et al. (2002) added 4% soybean oil to diets differing in fiber concentration supplied to Sarda ewes in the third month of lactation. For both of the fiber levels studied, the addition of the unsaturated oil significantly increased milk yield. Milk fat concentration was not affected, while milk protein concentration decreased.

The lack of effects in diets supplemented with CSFA on milk yield and persistency reported in the reviews of Chilliard and Bocquier (1993), Caja and Bocquier (2000) and Bocquier and Caja (2001) contrast with the results of the experiments we reported. These differences are not easily explained. Possible reasons may be related to differences in intake of the pasture in grazing experiments, depressed diet digestibility and altered rumen metabolism in those experiments in which all the supplemented fat was added in high concentrations in the concentrates (and not diluted in the whole ration). Also, often the concentrates were supplied few times per day (usually twice per day), while in other cases they were added in total mixed rations.

## **DIETARY PROTEINS AND LACTATION PERSISTENCY**

Optimal dietary protein concentration should be calculated by dividing the required metabolizable protein (PDI or MP depending on the system used) by the predicted DM intake. However, when this approach is used the diets balanced for PDI or MP are often rather low in CP concentration, with values ranging between 11% and 15% CP (DM basis) (Cannas, 2000; Cannas, 2002a; Cannas, 2002b). These values are also lower than those reported for lactating dairy cows (NRC, 1988). Low dietary CP concentrations usually decrease intake, feed passage rate and milk yield (Van Soest, 1994; Cannas and Van Soest, 2000). Moreover, several experiments in which various dietary CP concentrations were tested in lactating ewes found that the highest milk yield was obtained with dietary CP of around 17%-19% (DM basis) both in early (Gonzalez et al., 1982; Gonzalez et al., 1984; Robinson, 1987a) and mid-late lactation (Pulina et al., 1990; Cannas et al., 1998). This suggests that in many cases sheep require more protein than predicted by most feeding systems. Optimal CP concentrations for lactating ewes were reported elsewhere (Cannas, 2002b).

In many of the experiments in which high protein concentration improved milk yield, the diets included rather large amounts of escape protein (feed protein not fermented in the rumen and digested in the intestine) because either protein sources of low degradability were used or high intake and feed rumen passage rates were achieved.

As an example, an experiment previously presented (Tables 8 and 9 and Figure 16), in which different dietary protein and energy concentrations were tested in Sarda ewes in mid lactation (Cannas et al., 1998) will be discussed here. The highest milk yield was obtained with dietary CP concentrations close to 19% for both energy levels considered. In this experiment, the diets included (Table 8) two protein sources of low degradability (fish meal and corn gluten meal) that were eaten at very high levels of intake (DM intake above 5% of BW). This probably induced high passage rates (and then high feed protein escape) of dietary protein.

Since lactating ewes usually have higher levels of intake than cows, the concentrations of dietary CP found in the experiments above mentioned imply that lactating ewes should have a higher daily intake of CP per kg of BW than lactating cows to meet their requirements. The high CP requirement per kg of BW and the high requirement in escape protein may be explained by the fact that sheep require high quantities of sulfur-containing amino acids for wool production (Bocquier et al., 1987). This suggests that methionine, the essential amino acid required in large amounts for wool production, and some co-associated essential amino acids (e.g. lysine) may be

limiting. In fact, the lack of any specific essential amino acid may result in serious dietary imbalances, wastage of proteins and decreased milk yield. Thus, the positive effect of diets rich in escape proteins on milk yield may be explained with their ability to provide essential amino acids to sheep.

To verify if methionine or other essential amino acids limit milk yield in sheep, we reviewed some of the publications in which protected forms of essential amino acids were supplemented to lactating ewes (Table 12). In the majority of the experiments the addition of methionine or lysine slightly increased milk yield but only in few cases the differences were significant (Table 12). Excess of dietary protein can have negative effects on milk yield and persistency of lactation, because the energetic cost of disposing the nitrogen in excess is very high (12 kcal/g of nitrogen; Tyrrel et al., 1972). This means that one hundred grams of CP in excess of requirements cost to the ewe the same energy required to produce 200 g of milk. Excess of CP intake is common in sheep grazing immature pastures, in which the CP concentration is often higher than 25-30% of DM. Thus, especially when energy availability is limiting, diets too rich in proteins can cause reduction of milk yield. In addition, excess of ammonia tend to increase nitrogen retention in the body at the expense of milk yield and milk protein yield (Malik et al., 1999). Therefore, the utilization of pastures or feeds with high soluble protein content can substantially reduce milk yield and lactation persistency.

Dietary protein unbalances can be fairly easily monitored by measuring milk urea concentration, which in sheep is a powerful nutritional indicator (Cannas et al., 1998; Cannas, 2002b).

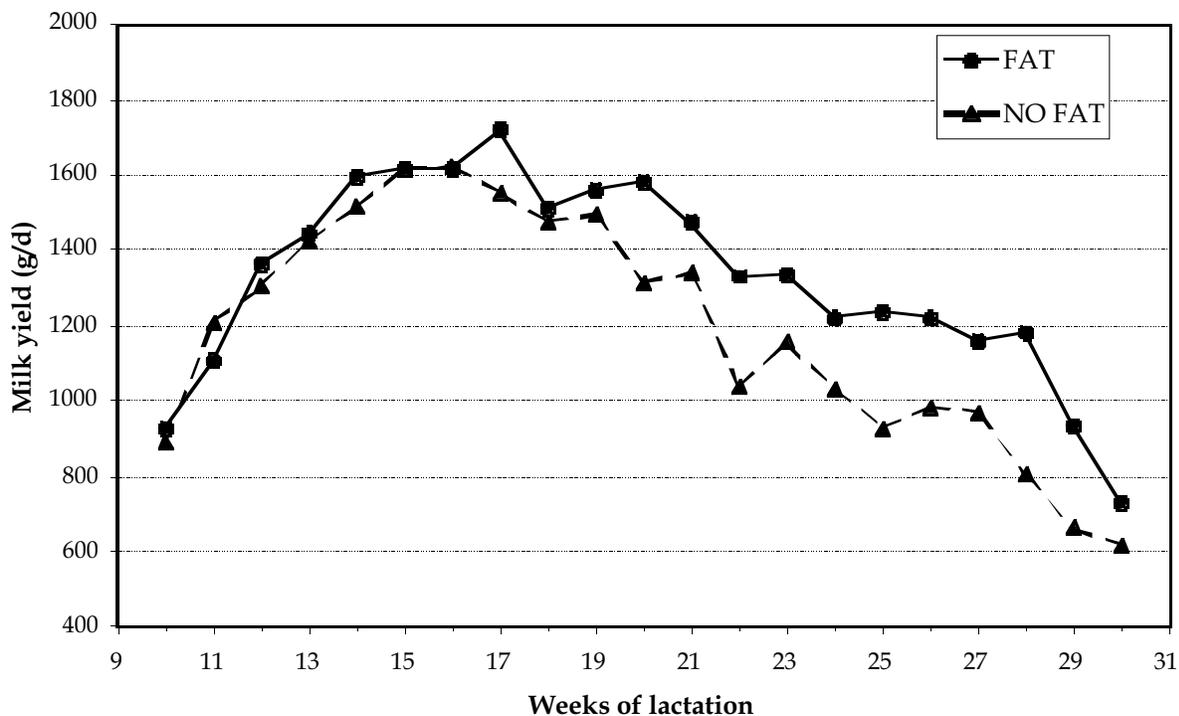


Figure 19 - Milk yield of Sarda ewes fed *ad libitum* pelleted diets supplemented with 4% of calcium salts of fatty acids (Rossi et al., 1991). • Diets supplemented; ▲ control.

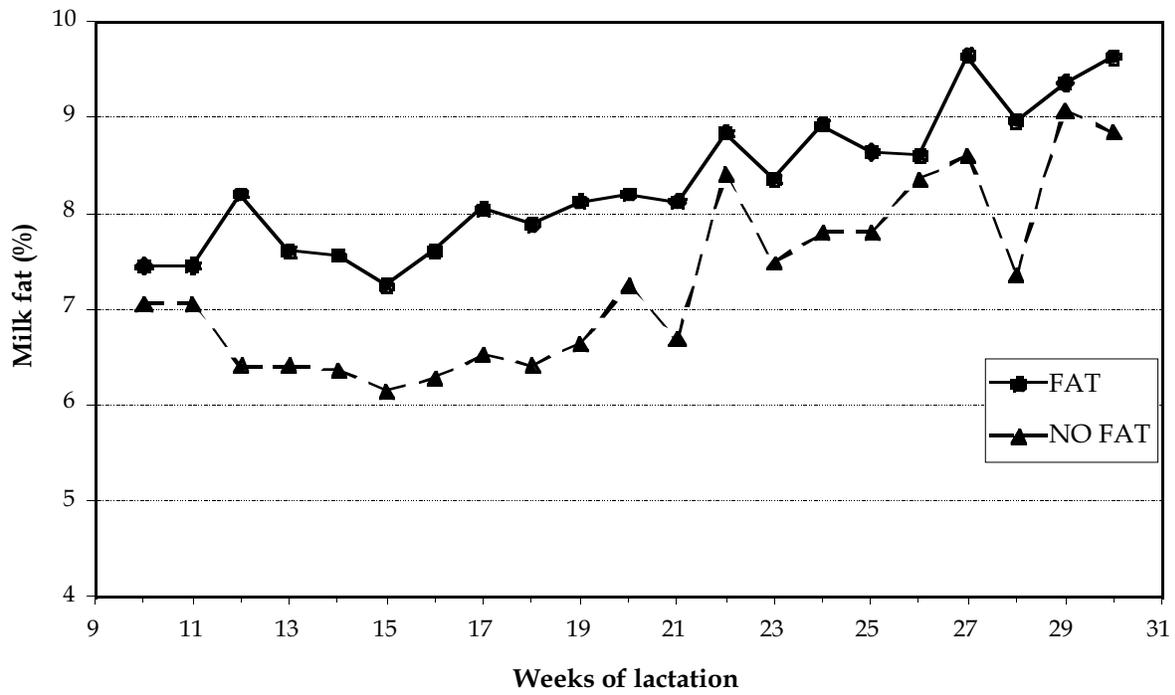


Figure 20 - Milk yield of Sarda ewes fed *ad libitum* pelleted diets supplemented with 4% of calcium salts of fatty acids (Rossi et al., 1991). • Diets supplemented; ▲ control.

Table 12 - Effects of supplementation of methionine and lysine on milk yield and protein content in ewes.

Author	Breed	Treatment daily doses	Milk yield g/d		Milk protein (%)		Month lactat. trial (d)	Length trial (d)
			control	treated	control	treated		
Barry, 1980	Romney	2 g L Meth + 95g Na Caseinate	1884	2016 ns			1	42
Floris et al., 1988	Sarda	6 g (for 30d) + 12g (for 12d) Meth	706	760 ns	4.50	4.70 ns	3	42
Olivieri et al., 1986 and Supplizi et al., 1986	Sarda	2.4 g Meth 1.2 g Meth		+ 288 ** + 93 ns	5.97	5.80 ns 6.09 **	1	140 140
Lynch et al., 1991 <sup>1</sup>	Black-face	3.80 g Meth + 3.97 g Lys - High CP diet	1900	2200 ns	5.46	5.60 <sup>3</sup>	1	49
Lynch et al., 1991 <sup>2</sup>	Black-face	5.05 g Meth + 4.26 g Lys - Low CP diet	1780	1760 ns	4.83	5.23 <sup>3</sup>	1	49
Baldwin et al., 1993	Dorset	2 g Meth	2110	2160 ns	4.74	4.60 ns	1	42
Sevi et al., 1995	Comisana	2.8 g DL Meth	644	665 ns	6.30	6.30 ns	2	112
Sevi et al., 1995	Comisana	5.6 g DL Meth	644	675 ns	6.30	6.40 ns	2	112
Sevi et al., 1996	Comisana	8.4 g Lys-HCl	644	774 *	6.29	6.14 ns	2	84
Sevi et al., 1996	Comisana	16.8 g Lys-HCl	644	613 ns	6.29	6.20 ns	2	84
Chiofalo et al., 1996	Comisana	4.9 g Lys + 1.4 g Meth	560	620 *	6.23	6.59 **	5	56

<sup>1</sup> The growth rate of the suckling lambs was higher in the treated vs. the control (509 vs. 433; P<0.05)

<sup>2</sup> The growth rate of the suckling lambs was higher in the treated vs. the control (382 vs. 458; P<0.05)

<sup>3</sup> no statistical tests were reported;

\* P<0.05 \*\* P<0.01

## CONCLUSIONS

Lactation persistency is controlled by a complex interaction of genetic, physiological and nutritional factors. For this reason, there are no simple and always successful nutritional strategies to improve lactation persistency. Milk yield in the second half of the lactation is markedly affected by the nutritional and non-nutritional events that occurred in the previous phases. Feeding techniques for the second half of the lactation should always keep in mind that sheep have been less selected for milk persistency than cows and tend to reduce milk yield rather easily when subjected to nutritional, but also environmental, stresses. Thus, the diet utilized and the nutritional status of the animals should be monitored by using nutritional indicators, such as BCS, milk urea or milk fat concentrations. The high variability in milk production among ewes of the same flock suggests that the animals should be divided in groups according to their level of production. If this is not done, it becomes very difficult to avoid excessive overfeeding of low producing animals and underfeeding of the ewes with the highest milk yield.

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# **COLLECTING AND MANAGING DATA EFFECTIVELY: A CASE STUDY FROM THE COMISANA BREED**

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## **Introduction**

Effective on-farm animal identification and production recording systems are critically important for farm management and for genetic improvement of an animal population. A genetic improvement program and good management are essential components of a viable dairy sheep industry.

In the Mediterranean, variable and sometimes inaccurate production recording systems are implemented by the local farmers associations. Difficulties in creating an efficient system for data recording and management are partly due to factors related with the peculiarity of the dairy sheep production system, such as poor animal identification and lack of farm infrastructures for milk recording.

The Experimental Zootechnical Institute of Sicily (Italy), the Farmer Association of Matera Province (Italy) and Cornell University (USA) have developed a specific information system for complete management of data from the flocks in the nucleus created in conjunction with the implementation of the breeding program to improve milk production in Comisana dairy sheep in the region of Sicily.

This information system facilitates monitoring and management of the sheep population and supports all selection and breeding decisions needed for the genetic improvement program. The information system was designed and implemented to work efficiently in wide varieties of management systems: in intensive or extensive systems using marginal land resources, with efficient or rudimentary farm housing, with milking parlor or milking by hand.

In this paper the different components of the information system developed to support the genetic improvement program for Comisana breed and its components addressing the collection of production and reproduction records, population management, genetic evaluation of animals and the mating program are presented.

## Animal Identification

Accurate identification of animals is a precondition for ensuring an efficient flock management and for implementing a genetic improvement program in the field. In the nucleus flocks enrolled in the Comisana breeding program, the electronic identification was adopted by using the rumen bolus system. This system is the result of a research project within the Idea (Electronic Identification of Animals) Project supported by the European Community with the objective to promote the electronic identification of livestock in Europe. The rumen bolus system has been tested in over one million animals.

The animals are identified using individual tags and ear tattoos immediately after birth and at six months of age the lambs receive the rumen bolus (Figure 1), which is ingested orally (Figure 2) and will permanently lodge in the animals' reticulum. The rumen bolus is a ceramic capsule (cylindrical shape and weighting 70gr) containing an ISOHDX type transponder of 32 mm. The transponder is a passive battery-less device functioning between - 25°C and + 85°C.

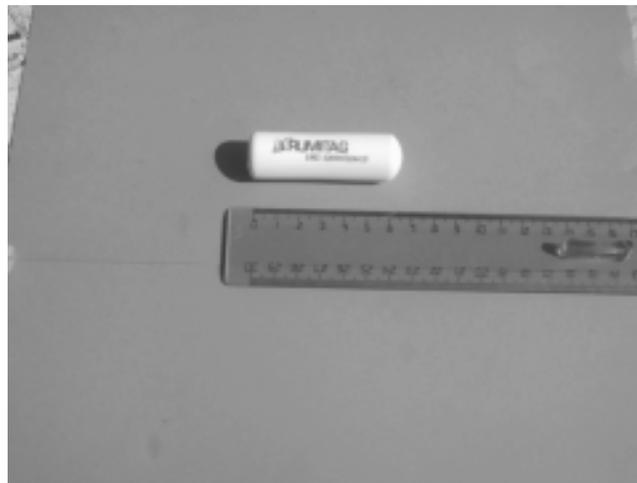


Figure 1 Rumen bolus microchip.



Figure 2 Ingestion of Rumen Bolus

When it is stimulated by the Portable Reader (Figure 3) emitting low frequencies electromagnetic waves, the microchip transmits a unique and inviolable number. The Stick Antenna (Figure 4) allows the production controller to identify each animal without having to closely approaching it as shown in Figure 5. The Portable Reader is connected to the Records Keeper (Figure 6), in fact a field computer, which associates the microchip number with the animal identification and allows the operator to enter the production and reproduction records for each animal in the flock.



Figure 3 Portable Reader.



Figure 4 Stick Antenna.



Figure 5 Reading animal identification in the field



Figure 6 Records Keeper.

## THE DATABASE

The database to store production and reproduction data for dairy sheep or goat records was developed by the Farmer Association of Matera Province (Italy) and is named *Progecom* (Figure 7).

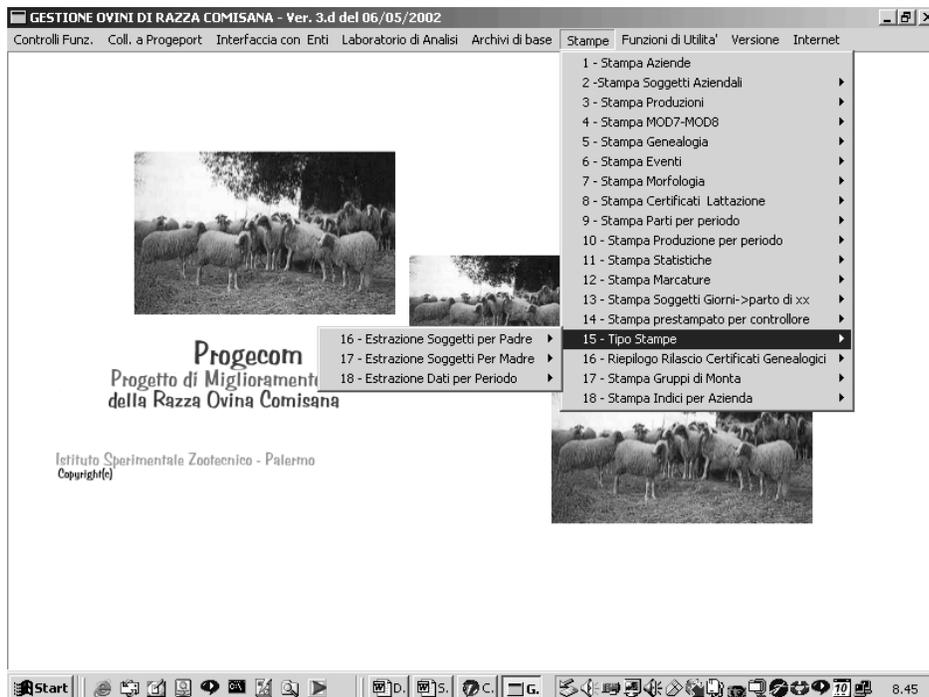


Figure 7 Progecom opening screen.

The program works on a PC with a Windows 95/98/NT/2000 operating system. The general structure and the main functions of the Progecom database are:

- 1. Farm identification and storage.** This function of the database stores various information related with the farm, such as name, location, tel. number, type of farm etc. Each farm has an unique code, which allows for fast and easy search of the database. The date when each record is collected is also automatically reported.
- 2. Animal identification and storage.** The animal identification is associated with a unique microchip number. All information related with the individual animal, such as sex, date of birth, sire and dam, farm, last event status code, lactation number, etc., are stored. The database allows for easy retrieval of productive and reproductive career of each individual animal.
- 3. Record collector identification.** The names of the technicians of the breed or farmer association who are responsible with the collection of records on each farm are recorded.
- 4. Productive and reproductive data management.** This function of the database allows the operator to collect the productive and reproductive data directly in the field, such as date and type of lambing, milk yield, other events like date of dry, animal sale or elimination, etc., and to transfer it to the main database. A number of editing filters are built into the system to ensure high accuracy of collected records. The lactation curve is also constructed for each ewe if requested.
- 5. Breeding group management.** This procedure assigns a ram to a single ewe or a group of ewes, either with natural mating or with artificial insemination. The operator enters the starting date and the last breeding date for each group as well as the result of the pregnancy diagnosis. When the date of birth is entered, the program automatically assigns the sire according to the time interval between the breeding dates of the group and the birth date of the lamb.
- 6. Milk composition storage.** The database can import the milk components, such as fat, protein, SCC, urea, lactose, total dry matter, etc., which will be associated to the milk yield records for the corresponding test day.
- 7. Genetic indexes storage.** The estimated genetic merit (breeding values) can be automatically imported and stored in the database.
- 8. Interrogating the database via screen reports.** The database provides a number of reports that have a direct application to the flock management. Some of them are: the list of the farm animals (the entire flock, the males, the lambs, etc.), milk production for each farm in each control, milk production in a predefined time interval for each farm, the list of animals that have performed higher than a predefined amount of milk, the productive and reproductive career of each individual, the breeding groups, the morphological evaluation of each animal, the list of ewes that have lambed in a predefined time interval, and the main statistical parameters. A image of the database that highlights the list of screen reports is in Figure 7.

## COLLECTING RECORDS IN THE FIELD

In dairy sheep, the collection of milk records on farm is particularly laborious and typically subjected to bias due to poor identification of individual animals. This is the reason why a specific field interface program has been implemented for the flocks involved in the Comisana breeding project. The field interface program consists of two software components named *Proport* and *Ovichip*.

Progport works on a Portable Personal Computer and is designed to manage the productive and reproductive data on farm. The software imports the records collected on farm and provides the farmer with all information related to the milking.

Ovichip works on the portable Keeper and has two important functions: it associates the microchip number with the animal identification and allows the operator to enter the individual milk production measured in the field.

This program allows the Records Keeper to interrogate the identification of animals and greatly facilitates the collection of records on farm and their transfer to the data-base, while maximizing the accuracy of the records. Figure 6 shows a phase of the milk recording.

## **THE GENETIC EVALUATION PROGRAM**

The *Genetic Evaluation Program* is an important component of the information system. The first function of the program is to edit the data coming from *Progecom* database and structure it in a format required by the genetic evaluation program.

The genetic evaluation program uses an autoregressive test day animal model (TDAM) developed by J. Carvalho *et al.* (1998). The computer software is based on a series of programs that build the incidence matrices according to the structure of the data, and computes the inverse of the genetic additive relationship matrices to be incorporated into the coefficient matrix of the BLUP mixed model equations.

The variance components, heritability and repeatability are estimated and used as inputs for subsequent genetic evaluation analyses in which the genetic ranking of all individuals in the data set is determined. In the second stage of the analysis, the breeding values (EBV) and accuracy of EBV are estimated for all animals in the data set after adjusting for the effect environmental factors such as farm, age, parity and days in milk.

## **THE MATING PROGRAM**

This component of the program allows the formation of breeding groups for progeny testing of young rams or for matching of available rams and ewes for breeding using a set of criteria chosen by the operator. The matching can be done based on age, production, location, genetic merit, etc, while controlling for the level of inbreeding of the future offspring.

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# **SUPPLEMENTAL FEEDING OF DAIRY SHEEP AND GOATS ON INTENSIVELY MANAGED PASTURES**

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Durham, New Hampshire**

## **Background:**

In the summer of 1998, I had a number of conversations with David Major, a dairy sheep farmer in Vermont, and with Keith and Leslie Quarrier, dairy goat farmers in New Hampshire. Those conversations centered around the difficulty both farms were having in determining if it would be worthwhile to supplement their lactating animals on pasture with a grain/concentrate supplement and, if so, how much concentrate/grain supplement should be fed. Both farms had many years of experience in developing and managing their pastures. As a result, their pasture quality was excellent and had been tested to show high nutritive value (>16%CP, >60% TDN).

In an attempt to answer these questions concerning supplementation, David Major had, the previous summer, conducted his own on-farm experiment. He randomly divided his dairy sheep flock (130 ewes) into two groups. One group was fed 1 lb of a corn/barley mix, the other group was fed 2 lbs of the same supplement. His results were that group 1 averaged 15 lbs of milk more per ewe for the lactation (150 days +/-) than group 2. Just the opposite of what he expected. However, because there had been no control group and no valid experimental design, the results were inconclusive at best and as David said, "it just goes to show how much in the dark we are". As a result of these conversations, I convened a meeting in the fall of 1998 which included David Major, the Quarriers, John Porter, UNHCE Dairy Specialist, Chet Parsons, UVMCE Sheep Specialist, and Heidi Smith, NRCS. The need for a research project to address these questions was confirmed and a decision to submit a proposal for a Sustainable Agriculture Research and Education (SARE) grant was made.

Subsequently, two well known and respected ruminant nutritionists, Dr. Doug Hogue from Cornell and Dr. Jim Welch from UVM, joined the group to help develop the grant proposal and assist with the study. Our proposal was for a three year study. SARE agreed to fund the project and we began the study in 1999.

## **Methods / Approach:**

The project used a team approach involving farmers, researchers, UVM and UNH Cooperative Extension, and NRCS personnel. The project was conducted at two on-farm sites, Major Farm (dairy sheep), Westminster, Vermont and Quarrier Farm (dairy goats), Acworth, New Hampshire. Dr. James Welch, UVM, developed the experimental design.

In year one, we used a Randomized Complete Block design. i.e. All available animals were identified according to previous milk production, genetic potential for milk production, number of offspring nursed, weight and age. Animals were assigned to blocks of three according to the above criteria. Animals within blocks were randomly assigned to treatments 1, 2, or 3. Each animal was identified by ear tag or tattoo and by a colored leg band for quick ID at milking. The sheep used for the study were all from David Major's flock. They had been systematically crossbred by David over the previous ten years and were a mix of Dorset, Tunis, East Friesian and Rambouillet. Their average lactation yield was approximately 300lbs / 150 day lactation. The goats used were all from the Quarrier herd and were mostly Sanaans with a few Nubian – Sanaan crosses. None of the animals in the study were less than two years of age.

The three groups received different levels a of nutritionally complete supplement designed by Dr. Doug Hogue, Cornell University (see appendicies for formula). This supplement was designed utilizing the current information available on feeding high milk producing sheep and goats and utilized readily available feedstuffs. The resulting supplement was a 14-16% protein, high-energy dairy pellet with 20% soybean hulls as a source of highly fermentable fiber. The supplement was balanced for vitamins and minerals for each species. The National Research Council's Nutrient Requirements of Sheep, 6<sup>th</sup> edition, 1985 and Nutrient Requirements of Goats, 1981, were used as guidelines to determine the nutrient requirement baseline on which the level of supplementation was determined.

All three groups were grazed together and allowed unlimited consumption of the same high quality pasture. Pastures at both farms were well established and consisted primarily of a white clover and bluegrass mix. However, a survey of plant species was done in year one by Dr. Matt Sanderson and some of his staff from the USDS Pasture Research Lab at Penn State. That survey identified over 40 plant species in the pastures. The pastures had been and continued to be intensively managed. The pastures were subdivided into small paddocks using electric fencing . The animals were given a fresh paddock after every milking (approximately every 12 hours). There was always sufficient pasture to provide unlimited grazing. Pasture fertility was maintained with manure and lime. At milking each animal received the supplement according to which of the three groups it had been assigned. After milking the animals returned to a single group. All animals received care at the best management level throughout the life of the project. Animal care was monitored weekly by Extension Specialists or a licensed veterinarian.

In years two and three, we redesigned the experiments based on our analysis of the previous year's data.

**The following measurements were taken in each of the three years of the project:**

Weight - all animals were weighed at the beginning and end of each experiment period.

Milk - milk was weighed and analyzed regularly during each experiment for fat, protein, milk urea nitrogen (MUN), and somatic cell count.

- Pasture - pasture quantity and quality was measured/sampled and recorded daily during each testing period. A rising plate pasture meter designed and made in New Zealand was used for quantity measurement. Quality was analyzed at the Dairy One forage-testing lab, Ithaca, NY.
- Health - animal health and overall condition was assessed by a licensed veterinarian at the beginning and end of each experiment. A condition score of 1 to 5 was assigned each animal at each of these times. Health treatments were administered under the direction of the veterinarian.

An intern on each farm assisted in taking these measurements and in recording and compiling the data. All milk production data compiled was statistically analyzed by Dr. Steve Judd, UNHCE.

### **Results:**

For the dairy sheep: in year one, following the methods detailed above, we compared three levels of concentrate feeding, .5 lb per ewe per day, 1.5 lbs per ewe per day, and 2.5 lbs per ewe per day. We found that there were no significant differences in milk yield or milk composition, or animal condition score between the three treatments.(see appendices for actual milk yield and composition figures)

Although not significantly different, the average milk yield and milk composition of the group fed 2.5 lbs per day was actually **lower** than the other two groups. We reasoned this was the result of the sheep reducing their consumption of pasture in favor of the supplement. Our hypothesis is that milk yield was reduced in the more heavily supplemented groups because the pasture was more nutritious than the supplement. We concluded that there was no reason for supplementing above the 1.5 level.

In year two we used a “switch-back” design to compare .5 lbs per ewe per day and 1.5 lbs per ewe per day. Again we found no significant difference.

In year three, we again randomly divided the flock into groups and fed one group .5 lbs per ewe per day, and the other group 1.5 lbs per ewe per day. However, we kept the groups on those treatments for the entire lactation with no “switch-back”. Again, there were “no significant differences”.

We concluded from our data that dairy sheep on well managed pastures lactating in the 3 lb/day range needed no more than .5 lbs per ewe per day concentrate supplementation. We didn't try zero concentrate supplementation because David Major felt that .5 lbs per ewe per day(.25 lbs/milking) was the minimum practical level of concentrate feeding necessary to attract the sheep into the milking parlor. It's interesting to note that eleven ewes in this study had average lactation yields >600 lbs/150 days, suggesting that a .5 lb level of supplementation may be adequate for ewes with the genetic potential for that level of milk production.

We used similar methods for the goats, although the feeding levels were higher at 1., 3.0 and 5.0 lbs per doe per day. We found that the does responded to increased concentrate. Our conclusion/recommendation for dairy goats grazing high quality pastures is to feed concentrate at a ratio of 1 lb of concentrate for each 3 lbs of milk yield.

In year three of the goat study, we compared the concentrate with fermentable fiber (soybean hulls) with a concentrate exactly the same except without fermentable fiber.. This comparison was done during lactation only. The results showed no significant difference in milk yield, milk composition, or animal condition score between the two formulations. The Quarriers did observe that by feeding the concentrate with fermentable fiber the last 4-6 weeks of gestation, they significantly reduced what had been a fairly high incidence of ketosis . For them, this was the most important economic benefit of this project.

**Other results from this project include:**

(1) a comprehensive data set on the nutritive quality of well managed pasture collected from the same pastures over three consecutive pasture seasons. These data show levels (on a dry matter basis) of crude protein averaging over 20% and as high as 28%, of TDN averaging over 60% and as high as 67%, and relative feed values averaging over 110 and as high as 159.

(2) A comprehensive data set on sheep and goat milk yield and milk composition (including fat, protein, MUN, SCC) collected from a significant number of animals (100 ewes, 60 does) and over three consecutive lactation periods. The sheep milk data are especially useful because the sheep dairy industry in North America is so young that data such as these collected under controlled conditions are not readily available.

(3) A clear demonstration that high quality data, that can serve as a solid basis for management recommendations, can be successfully generated from on-farm experiments through the collaboration of university researchers, Extension and USDA agency staff, dedicated farmers, and SARE funding support.

**Impacts:**

The primary impact we were after was the answer to our question, “what is the optimal level of concentrate supplementation needed for lactating sheep and goats grazing intensively managed pastures?” As detailed above, we were successful in achieving that impact.

**Other impacts from our project include:**

(1) Cost savings to dairy sheep producers who adopt our results of approximately \$13/ewe per lactation (see detail in next section of this report).

(2) Most dairy sheep and many goat producers in the VT-NH-MA area now use the concentrate formulated by Dr. Hogue for this project.

(3) David Major credits his involvement in the project as the primary reason his per ewe milk yield increased over 50% during the three years of the project.

- (4) The camaraderie that developed between project participants was very valuable and was cited by each participant as a personal impact of the project.

### **Economic analysis:**

The results from the project allowed us to do a very straightforward economic analysis.

For the dairy sheep producer, the economic benefit is substantial. Previous to our work, dairy sheep producers were typically feeding 1.5 - 2.0 lbs of supplement/ewe/day in the form of whole grain or pelleted concentrate. Also, scouring and other symptoms of acidosis were commonly seen.

### **Our results point to two economic benefits for dairy sheep producers:**

- (1) Our recommendation of feeding .5lbs of supplement/ewe/day rather than 1.5 -2.0 lbs/ewe/day saves the cost of 1.0 - 1.5 lbs supplement/ewe/day. At an average cost of \$.09/lb, times an average 150 day lactation, gives a savings of \$13.50 - \$20.25 per ewe. Multiply this times the number of ewes in a flock (in Major's case over 100 ewes), and the savings are substantial.
- (2) The other benefit is the improvement in milk production. David Major reported a 50% increase in milk production over the three years of the project (see letter in appendices). He credits most of this increase to improvement in the metabolic health of his ewes due to the proper balancing of their pasture diet with a concentrate supplement that contained 20% fermentable fiber. If we credited the project with just a 20% improvement in milk production, then the increase in income would be calculated as 20% times 3 lbs/milk/ewe/day times 150 days times the price of milk at \$.70/lb equals an increased income of \$63/ewe/lactation.

The economic benefits to a goat producer were not as direct. Our work did not point out any savings in feed costs, however, the generation of data to substantiate the recommendation of feeding supplement at the ratio of 1 lb of supplement to every 3 lbs of milk will likely result in economic benefits due to more accurate feeding of supplement. The Quarriers also reported significant increases in milk production over the three years of the project which they also credit to the improvement in the metabolic health of their does (see letter in appendices). The Quarrier's also reported that the use of Dr. Hogue's concentrate formula reduced a serious ketosis problem in their herd.

## **Appendices**

### **1. Study Team Members:**

#### **Team Leader:**

Bruce Clement, UNHCE, 59 College Rd., Durham, NH 03824

#### **Farmers:**

David Major, 875 Patch Road, Putney, VT 05346

Keith and Leslie Quarrier, POB 125, Alstead, NH 03602

**Research Advisors:**

Dr. Douglas Hogue, Professor Emeritus, Cornell University, 255 Morrison Hall, Ithaca, NY 14853

Dr. James Welch, Professor Emeritus, University of Vermont, 16 Raymond Rd, Colchester, VT 05446

**Technical Advisors:**

Carol Delaney, UVM, Small Ruminant Dairy Specialist, 212 Terrill Hall, UVM, Burlington, VT 05405

Dr. Peter Erickson, UNH Dairy Specialist, 129 Main St., Kendall Hall, Durham, NH 03824

Dr. Stephen Major, DVM, Green Mtn. Bovine Clinic, 27 Bovine Ave., W. Chesterfield, NH 03466

Chester Parsons, UVM Sustainable Ag. Specialist, 278 S. Main St., St. Albans, VT 05478

John Porter, UNH Dairy Specialist, 315 D.W. Highway, Boscawen, NH 03303

Heidi Smith, NRCS, Rt. 1, Box 315, Walpole, NH 03608

**Ag Economist:**

Mike Sciabarrasi, UNH Ag Business Management Specialist, 56 College RD, James Hall, Durham, NH 03824

**Statistician:**

Dr Stephen Judd, UNH Information Technology Specialist, 59 College Rd, Taylor Hall, Durham, NH 03824

**2. Testimonials:**

February 21, 2002

TO: Bruce Clement

FROM: Doug Hogue

RE: Some comments on SARE project.

I know of no other data set or data analysis that is as carefully or completely collected and recorded in an on-farm experiment with milking sheep and lactating goats.

Provides a data set on the production level, lactation curves and milk composition under controlled conditions, the results from which should be applicable to many on-farm situations.

The feeding level comparisons serve as a solid base for supplemental feeding recommendations for both milking sheep and lactating goats.

While not comparative, the diet formulation should be useful, especially for lactating goats in the prevention of metabolic disturbances.

Level of participation by the cooperating producers was excellent and they should have confidence in the results and the application of the findings.

These producers most probably will communicate with others and thus their confidence should enhance the application of the resulting recommendations throughout the northeast.

Also while I don't think the results were surprising or unexpected based on our nutritional knowledge, many producers milking either sheep or goats base many of their procedures on hearsay or personal opinion and the data collected here should connect them back to a more scientific base.

This SARE project "committee" consisted of producers, county and state level extension personnel as well as research scientists which gave the project a lot of "oomph" in both breadth and depth. This contributed greatly to the overall success.

These comments are all of a "general" nature and should be used as an add-on to the specific results garnered from the data on production, etc. However I think they are important to realize the potential usefulness of the project results.

The camaraderie developed between and among the many project participants alone should enhance future developments in this general area.

Finally, the leadership of the project coordinator (or whatever his title is) (I mean you, Bruce) cannot be overestimated in bringing off a rather intense 3-year effort.

Hope these are useful.

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Bruce

The most significant outcome of the project was the finding that the sheep were able to meet their lactation requirements from grass alone. The standard thought is that lactating ruminants can not consume enough roughage to maximize lactation output. This is certainly true of dairy cattle and was apparently true to some extent with the goats. I think that the sheep were not lactating at a level that would require nutrients above their ability to eat grass to maximize milk output. With the higher milk-producing sheep, grass intake was certainly at a very high level. The experiments were remarkably well run, for field trials. This was due to several factors, but most important, the high quality of the owners. They were very capable people with a high level of interest and persistence.

James Welch

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Jan. 10, 2002

To Whom It May Concern,

We feel very fortunate to have been asked to be a part of this SARE grant experiment. Although we hoped for more similar results to what the Major's sheep farm found, which would have been very exciting, we had no big surprises with the results we got. It still felt like very worthwhile three years. The committee, which Bruce put together, was terrific and everyone worked incredibly well together. Even though we put the animals through a lot of feed changes, which we expected to hurt our production, our production actually increased significantly. We credit this a lot to the concentrate that Doug Hogue formulated for the experiment, which appeared in early lactation to help out with Ketosis problems and got the goats through kidding transitions smoother than ever. Once they settled into milking the feed wasn't as important, but having the grant gave us a focus on the farm, which made a big difference. Steve Judd helped so much with getting all of the farm information into the computer on a Data Base program. This makes all of our record keeping much more thorough and easy to use. Jim Welch was great to have on the committee because he has collected so much data himself, giving him area 1 understanding of how best to approach that end of the project. Having the vet asses the herd regularly was very reassuring. We looked forward to every meeting. Everyone's support and enthusiasm for the project was very motivating and helped us keep focused on what we were doing all the time.

We plan to continue freshening our herd with Doug's formula and will feed out concentrate according to milk production using the quantities that the experiment showed best. I'm not sure how many other farms have gained from what we did, but there is definitely a lot of curiosity to hear about it. I just wish we had three more years!

Keith and Leslie Quarrier

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Final Notes on the SARE Funded Research Project on Feed Supplements for Pasture Based Small Ruminant Dairies -David Major- 1-28-02

The recently completed 3 year long research project on feed supplements for pasture based small ruminant dairies was a definite success from the point of view of Major Farm, the farm that represented dairy sheep in this study. The process of developing and implementing the research guidelines went well. The results proved interesting and they will have a substantial impact on how we operate Major Farm in the future. With some luck and communication, the results may be able to help other pasture based northeast sheep dairies lower their input costs and increase their production as well. Process: Bruce Clement, the chief architect and coordinator of the project did an outstanding job assembling an experienced and committed group of extension and research professionals to help design and oversee the project. This group of advisors obviously appreciated the value of on-farm research and seemed willing to work around the limitations that go along with such research -designing the experiment to fit in with the scheduling and equipment peculiar to Major Farm. In retrospect, the one constructive criticism I have is that we could have profitably put more effort in defining exactly what pasture data would be useful and analyzing it better. By the end of the study we learned that the pasture portion of the sheep's diet was the most critical portion in determining their production; had we known at the beginning, we might have put more emphasis on the pasture data.

**Results:** From my point of view, the two most important results of our research are, 1) a lower protein, high fiber pelleted concentrate is a good choice supplement for dairy ewes on high quality pasture, and 2) so long as the dairy ewes have continuous access to high quality pasture, they do best on very low levels of supplement, meaning .5 pound per day or less.

**Usefulness:** The effect on our farm of our new found knowledge as been profound and it will continue to be so in the future. Partly as a result of management changes instituted during the course of the SARE research, our per ewe milk production has increased 50% in three years. In the future, we will be able to reduce our per ewe feed bill with the knowledge that we can rely more heavily on pasture and reduce the level of supplemental concentrates without cutting the ewes short.

The results of this research are relevant to all sheep dairies. I'm sure others will find the results useful as soon as they learn about them through conferences and the media. I am happy that I could help in a research project that finished up with such practical, useful results for a segment of the agricultural community.

Sincerely, David Major

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### **3. Concentrate formula:**

Bruce,

As you know, depending on availability we were using either soy hulls or beet pulp in the ration for the SARE project. The formula as designed and typically shipped for the 14% was:

Fine Corn Meal 567  
Ground Beet Pulp 380  
Wheat Middlings 364  
Red Dog Wheat 200  
Distillers Grains w/Solubles 150  
48% Soybean Meal 110  
Molasses 80  
Bakery Product 50  
Limestone 42  
Salt 20  
Dicalcium Phosphate 15  
Pellet Binder 12  
NEF Sheep Premix 10

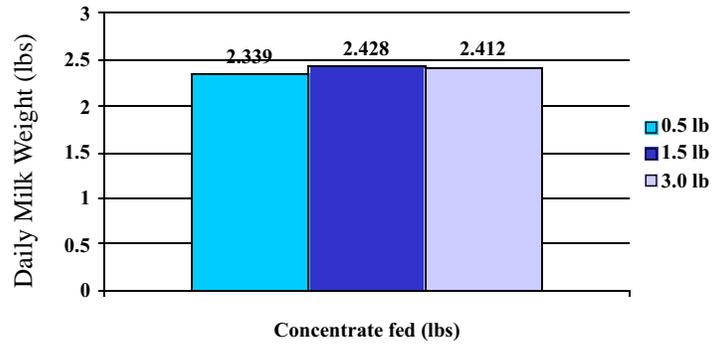
Thanks again for your interest in New England Feeds for this project. We appreciate the opportunity to have worked with you the producers who participated in this project.

Please don't hesitate to call if you have any questions.

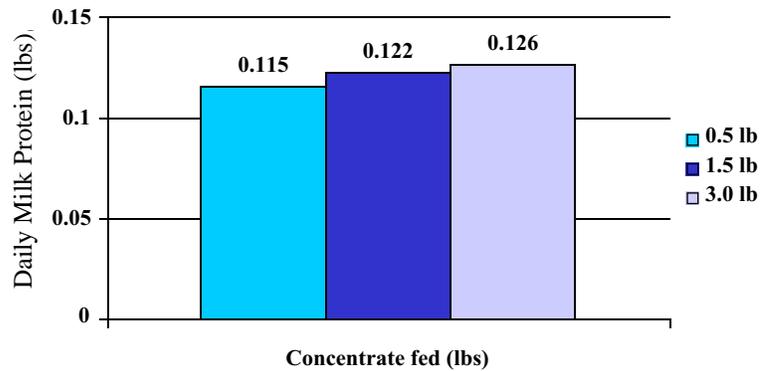
Gordon Smith, New England Feeds, Inc., 22 Kimball Place, Fitchburg, MA 01420  
(800) 545-6655 [gsmith@newenglandfeeds.com](mailto:gsmith@newenglandfeeds.com)

#### 4. Statistical Data

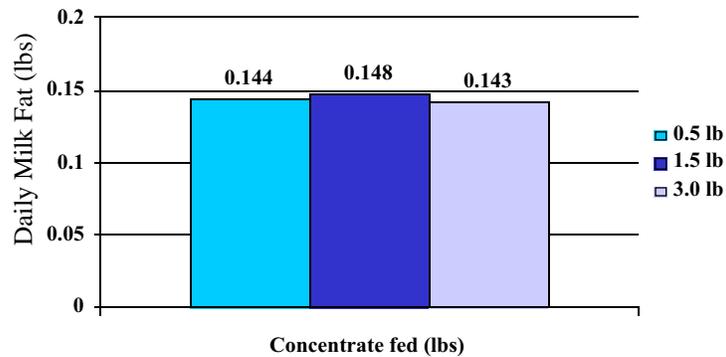
### Sheep Daily Milk Weight vs. Concentrate Fed (1999)



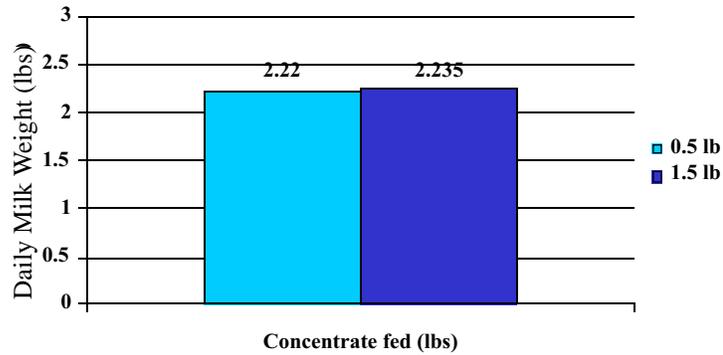
### Sheep Daily Milk Protein vs. Concentrate Fed (1999)



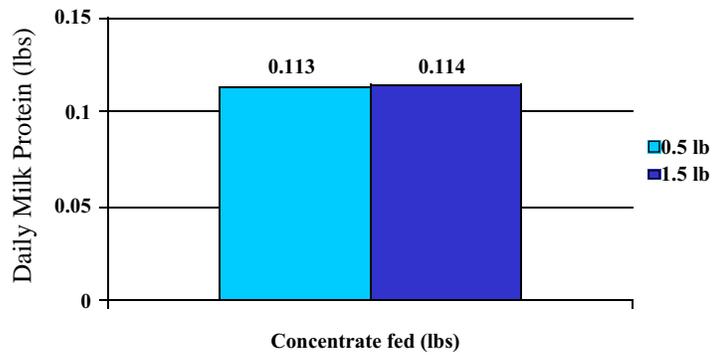
### Sheep Daily Milk Fat vs. Concentrate Fed (1999)



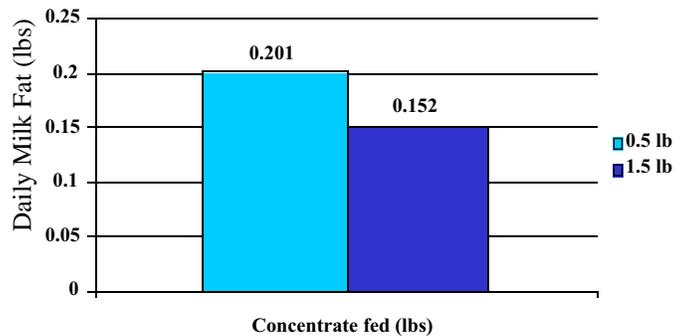
## Sheep Daily Milk Weight vs. Concentrate Fed (2000)



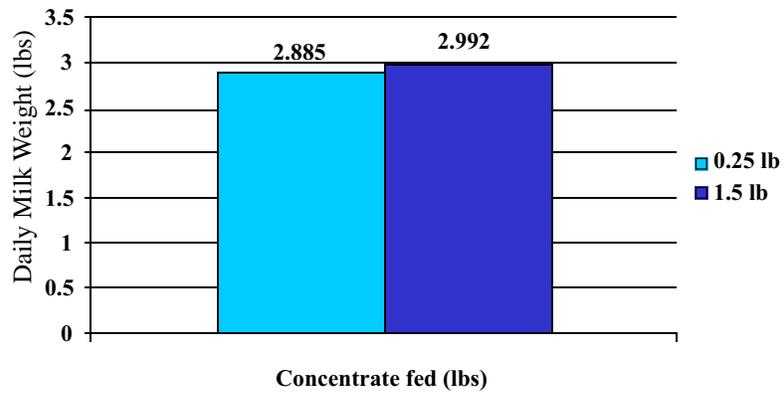
## Sheep Daily Milk Protein vs. Concentrate Fed (2000)



## Sheep Daily Milk Fat vs. Concentrate Fed (2000)



## Sheep Daily Milk Weight vs. Concentrate Fed (2001)



## **FLOCK HEALTH MANAGEMENT FOR DAIRY SHEEP**

**Mary C. Smith DVM and Susan M. Stehman VMD**

**New York State College of Veterinary Medicine  
Ithaca, New York**

Dairy sheep producers usually have a background of experience with farm management and disease and parasite control in less intensively managed sheep before they develop a commercial dairy operation. This paper will assume knowledge of vaccination protocols and parasite control, abortion diseases, foot diseases, lambing problems and care of the neonate. Emphasis will be placed instead on feed-related problems of the ewe, drug residues, care of the early-weaned lamb, and chronic diseases that are all too often purchased when assembling a dairy flock. Brief mention will be made of udder problems, but mastitis is discussed in more detail elsewhere in this symposium.

### **Listeriosis**

Producers looking for better forages to increase milk production from their dairy ewes sometimes are tempted to try haylage, baylage, or corn silage or to acquire manger sweepings from dairy cattle as a cheap source of feed. One of the greatest hazards of feeding ensiled forages is the presence of *Listeria monocytogenes* in poorly fermented feeds. This organism is ubiquitous in the environment but multiplies at cool temperatures in silages with a pH above 5.5. Silage from Ag Bags or wrapped bales may include deadly amounts of the organism if soil contaminated the forage, holes developed in the plastic wrapper, or the forage was too mature/dry to ferment properly when ensiled. Manger sweepings often include chunks of spoiled silage rejected by the cows. Cows are much more resistant to listeriosis than sheep, so absence of disease on the cattle dairy is no indication that the feed will be safe for sheep.

In a Scottish study, the risk of listeriosis in sheep increased 8 fold with silage feeding. Inoculants and preservatives decrease the risk but are expensive. Wrapping bales where they will be stored instead of spearing the wrapped bale to move it is very critical, and accidental holes in the bale wrapper must be covered with appropriate tape. If silages are fed, spoiled portions should be discarded. The manger should be cleaned daily and the uneaten feed removed from the barn rather than thrown into the pen as bedding. No vaccine is available in the USA to protect against listeriosis.

Listeriosis can appear as a neurologic disease (circling, facial nerve paralysis, dropped jaw, twisted neck) in weaned lambs or adults. This disease is rapidly fatal though some cases respond to high dose penicillin, oxytetracycline, or florfenicol. Listeriosis can also cause abortion in late pregnancy and the diagnosis will depend on laboratory cultures. Some neonatal lambs will be septicemic or found dead with multiple tiny abscesses in the liver. It is also important to realize that silage-fed animals are more apt to shed *Listeria* in their feces and milk than are hay-fed sheep. Fresh cheeses made from raw milk or aged cheeses recontaminated in the cheese cellar or refrigerator can cause serious illness or death in humans.

## Copper Toxicity

Copper is a trace mineral that is necessary for the health of the sheep. The actual requirement depends on the level of molybdenum in the diet, and to a lesser extent the calcium and sulfur concentration. According to the NRC's Nutrient Requirements of Sheep, the requirement for copper in the overall diet on a dry matter basis varies with the age and status of the sheep. Lactating ewes will need a lower concentration of copper in their feed than growing lambs.

NRC recommended dietary copper concentration (ppm, dry matter basis)			
	Growth	Pregnancy	Lactation
Molybdenum <1.0 ppm	8-10	9-11	7-8
Molybdenum >3.0 ppm	17-21	19-23	14-17

To avoid both toxicity and deficiency of copper, the copper:molybdenum ratio should be 6:1 to 10:1. Suffolk and Texel sheep absorb copper more efficiently and are at greater risk of toxicity. In a report from Sweden, East Friesian dairy sheep were particularly susceptible to copper poisoning, but it was not clear if this was a breed characteristic or the result of feeding high levels of concentrates to the ewes to support milk production.

A sheep consuming excess copper gradually builds up stores in the liver over several months while appearing healthy. After some stress, acute copper toxicity appears and the sheep is suddenly lethargic and off feed. The sclera (white of the eye) is yellow from jaundice and the urine is coffee colored. Treatment is rarely successful. Some affected sheep die with only hemorrhages in various organs found at gross necropsy. Other suddenly dead sheep have no lesions but histologic examination of the liver reveals severe necrosis and analysis verifies a very high copper concentration in liver or kidney.

Prevention of copper toxicity in dairy sheep should be based on knowledge of the mineral concentrations in forages, grains, and supplements. Trace mineralized salts and concentrate feeds formulated for other species should not be fed unless verified to have a safe copper content. Dairy cattle, swine or horse feeds are sometimes the source of toxic amounts of copper, while in other cases a red salt block is incriminated.

## Pregnancy Toxemia and Ketosis

If there is severe undernutrition or just a protein deficiency in late pregnancy, udders will be small and colostrum production decreased at time of parturition. Lambs may die of hypothermia or starvation at about the time the ewe's udder fills with milk. The colostrum antibody production by the ewe and therefore absorption by the lamb will also be adversely affected, potentially leading to higher lamb mortality from infectious diseases.

Late pregnant ewes and heavily lactating ewes that are off feed should be checked for ketones in the urine, using commercial test strips or pills. The pill or strip turns purple when ketone bodies are present. Urine can be collected when the ewe rises as a person enters the pen, or the nostrils can be held closed for up to 45 seconds to induce urination by stressing the ewe. Many animals with pregnancy toxemia are very dehydrated, and in addition the bladder may be empty, so release the sheep before it dies of anoxia. Other signs of pregnancy toxemia include abnormally small fecal pellets (an indication that the animal is eating poorly), reluctance to rise, self-isolation from the flock, or teeth grinding.

Initial treatment of the ewe with pregnancy toxemia includes 2 ounces of propylene glycol orally 2 to 3 times a day, 60 ml of calcium borogluconate subcutaneously divided into 4 sites, mixed B vitamins or thiamine, and intravenous dextrose (60 ml of 50% solution diluted to slightly less than 500 ml in sterile water). Animals that are acidotic and dehydrated will benefit from large volumes of intravenous fluids and sodium bicarbonate. Antibiotics are indicated if the fetuses may have died. If the ewe is unresponsive and unable to rise, the prognosis is grave. If the animal is not eating by the next morning a C section may be attempted to try to save its life. If there is partial response and the last possible breeding date is known, induction of parturition with 20 or 25 mg of dexamethasone may be attempted if the ewe has reached day 139 of pregnancy. Induction requires approximately 48 hours, and will come too late for severely affected animals.

Prevention of pregnancy toxemia in ewes pregnant with two or more lambs is no different for dairy ewes than for ewes that only suckle their young. The protein and energy needs of the dam and the developing fetuses must be met without causing a grain overload/indigestion situation. The secret is good quality forage, with supplementation of perhaps a pound of grain per ewe per day the last 3 to 4 weeks of pregnancy. The grain needs to be introduced gradually and with ample feeder space. Yearling ewes should be fed separately from adults to minimize competition. Older ewes that have lost molars may need a pelleted roughage source to supply their nutritional needs.

### **Hypocalcemia**

Although it is rare for sheep to have a hypocalcemic episode similar to milk fever of dairy cows at the time of lambing, late pregnant and heavily lactating ewes are especially susceptible to calcium deficiency. Dietary oxalates increase susceptibility. Hypocalcemia may be precipitated by exercise, as when the sheep are driven in from pasture or chased by dogs. The sheep becomes too weak to continue or to get up and may lie on its sternum with the hindlimbs extended out behind it. Often the head is held low with neck extended, and the breathing is labored as if pulmonary edema or pneumonia were present. Ewes that have been lactating heavily may be still on their feet but off feed, cool and trembling. Fecal output and rumen contractions are decreased and a mild bloat may be observed. Ewes that are calcium deficient at the time of lambing may be slow to expel their lambs, such that dystocias or stillbirths result.

Treatment of hypocalcemia requires immediate administration of calcium to restore muscle function before the animal dies of heart failure. A commercial 23% calcium borogluconate

solution is used; avoid the combination products with phosphorus and dextrose added. A veterinarian will usually give 60 ml (cc) intravenously to a ewe that is unable to rise, but this must be done very slowly to avoid provoking potentially fatal irregularities of the heart beat. Less severe cases or instances where the diagnosis is not certain are handled with 60 ml of the 23% solution given subcutaneously, in four sites such as high and low behind the shoulders on each side. Goat owners report that Tums™ antacid pills are readily accepted by their animals and provide a calcium source in times of emergency or heavy production, as each pill contains 500 mg of calcium. By comparison, 500 ml of the injectable 23% calcium gluconate solution contains 10.7 g of calcium and the 60 ml sheep dose contains 1284 mg.

Prevention of hypocalcemia in sheep may require supplementing the diet of late pregnant and lactating ewes by addition of dicalcium phosphate to the trace mineral mix offered on pasture. Grain rations formulated for lactating ewes usually contain supplemental calcium. In dairy cattle feeding, alfalfa is often avoided in the diet of dry cows, not because it is too high in calcium but because high potassium levels in heavily fertilized alfalfa interfere with magnesium absorption, and low magnesium then induces hypocalcemia. If dairy sheep are being fed alfalfa hay or haylage from cow dairy farms, avoid feeding forages with a potassium concentration substantially above 1%. Based on recommendations for dairy cattle, the potassium to magnesium ratio in the ration in late pregnancy should not exceed 4:1.

### **Grain Overload**

Consumption of excessive amounts of rapidly fermenting carbohydrates leads to production of acetic and butyric acids in the rumen. As the pH of the rumen contents drops, acid-loving bacteria are favored. Streptococci and lactobacilli overgrow, producing lactic acid and driving the pH even lower. When the rumen pH drops below 5.5 the buffering capacity of bicarbonate in the saliva has been exceeded. The sheep is depressed and off feed. The body temperature can initially be slightly elevated, but drops below normal as the toxic indigestion progresses. Fluid is pulled out of the bloodstream and into the rumen, causing a characteristic splashy consistency that can be heard if the sheep's body wall is succussed (punched rapidly) on the left side. The eyes sink as dehydration increases. If the sheep lives a day it will develop diarrhea. If the animal has not been well vaccinated against enterotoxemia (two doses approximately one month apart followed by boosters at least once if not twice a year and especially 3 to 4 weeks prelambling), the overgrowth of *Clostridium perfringens* bacteria in the intestine will produce a rapidly fatal toxin. Interference with the production of B vitamins by normal rumen bacteria can lead to polyoencephalomalacia, which will cause blindness, elevated head, and eventual convulsions as brain cells are deprived of glucose. The off feed situation produced by a mild indigestion can throw a late pregnant ewe into pregnancy toxemia.

Treatment of grain overload begins with removing all grain from the group and offering dry hay. If the sheep is willing to eat the hay, the saliva produced while chewing the hay will help to return the rumen pH to normal. More severely affected animals will need more support from a veterinarian, including intravenous fluids (perhaps 5 liters) with added sodium bicarbonate to correct the acidosis. Calcium (60 ml subcutaneously divided into four sites), thiamine (10 mg/kg

several times a day by any route) and a single oral dose of 500 mg of a tetracycline product to slow bacterial fermentation are typically given. A particularly valuable animal that is not eating hay by the next day can be given a liter of cow or sheep rumen fluid (collected from a fistulated cow or an animal at slaughter) by stomach tube, to reestablish normal rumen flora.

Prevention of grain overload requires careful management of the sheep. The first line of defense is good forage so that large amounts of grain are not needed to support growing fetuses or high milk production. Grain should be coarse rather than finely ground, to slow its digestion. Grain should be introduced gradually over a week, to supply approximately one pound per ewe and a pound per lamb being raised in early lactation. If more grain is needed, buy better hay! Divide the grain feedings into two or more per day if more than a pound is needed per day. Equally important in preventing grain overload is having adequate feeder space so that all ewes can eat their fair share of grain at the same time. Fort Knox level security on the grain storage facility is also mandatory.

### **Drug Residues in the Milk**

Only one antibiotic is labeled for sheep with zero milk and meat withdrawal. That is ceftiofur (Naxcel™) which is a prescription antibiotic specifically labeled for sheep at 0.5 to 1.0 mg/kg (1 to 2 ml/100 pounds) once a day intramuscularly. Reconstituted Naxce™1 can be kept refrigerated for up to 7 days or frozen for up to 8 weeks without loss of potency.

All other antibiotics and most dewormers will cause contamination of the ewe's milk and meat if a withdrawal period is not adhered to. Very few products are labeled for use in sheep (see <<http://www.nrsp-7.org/MUMSRx/>> using Internet Explorer), fewer are currently marketed, and information is not given for milk withdrawal at this website. Labeled meat withdrawals for dewormers include Valbazen™ at 7 days, Ivomec Oral™ at 11 days and Levasole™ at 3 days. Although procaine penicillin G is labeled for sheep with a meat withdrawal of 9 days, this is at a dosage of 1 ml per 100 pounds once a day, and almost no infections of sheep are susceptible to such a small dose. Thus dairy sheep producers must work closely with their veterinarians to establish safe meat and milk withdrawals, to avoid residues in products sold and to avoid interference from antibiotics or anthelmintics (some of which are antifungal) with production of cultured cheeses.

The flock veterinarian, the only person allowed to prescribe extralabel drug use, can obtain guidance in establishing withdrawals from FARAD, the Food Animal Residue Avoidance Database. FARAD has a website at <<http://www.farad.org/>> under revision and a hotline for veterinarians on the east coast at . FARAD has previously published recommendations for extralabel use of oxytetracycline in sheep, indicating that because of rapid elimination of the drug after IV and IM administration, the labeled withdrawal periods for cattle are usually adequate. A milk discard of at least 96 hours (144 hours for multiple or high doses) should be used, followed by residue testing. For Ivomec Oral, FARAD has recommended a 9 day milk withdrawal for goats but has not published a recommendation for dairy sheep. Written records of all extralabel drug use must be kept for 2 years.

Although vaccines typically have a 21 to 60 day meat withdrawal, they have no milk withdrawal.

Increasing numbers of scientists and newsmongers question the use of antibiotics in food producing animals, contending that the practice may favor the development of antibiotic resistance in organisms that cause human diseases. Sheep producers need to adhere closely to the law regarding extralabel drug use. Specifically, any use of drugs not labeled for sheep, or higher dosages of the drugs or a different route of administration is forbidden unless prescribed by a veterinarian familiar with the animal being treated or the health and management of the flock. This veterinarian must either examine the animal or make “regular and timely visits” to the flock. Advice gleaned from a drug catalog or even a sheep conference cannot be translated into extralabel drug use unless this is approved by the flock veterinarian. The aim of the legislation is not to make health care expensive or to support veterinarians but to keep meat and milk free of drug residues. A dairy flock needs to be especially careful of drug residues, to protect the “natural” or “green” associations that consumers make with sheep products. The flock veterinarian also can assist in improving management and nutrition to decrease the need for drug usage.

Certain drugs are absolutely, totally, and unquestionably forbidden in all sheep for any reason, no matter if the animal will be used in the future for production of meat or milk or not. These forbidden drugs include Baytril (enrofloxacin), chloramphenicol, metronidazole, nitrofurazone, and clenbuterol. Sheep producers who obtain veterinary services from small animal practitioners need to be aware of this list, as unfortunately the veterinarian who sees very few food animals or thinks of them as ruminating pets may be unaware of recent changes in the law. It is illegal to mix any extralabel drug into feed. Coccidiostats are not permitted in the feed of ewes producing milk for human consumption. The extralabel use of drugs for production purposes, including estrus control, is also forbidden under the current law.

### **Skin Diseases of the Udder**

Any condition that damages the health of the skin near the teat opening will predispose to colonization with bacteria, notably *Staphylococcus aureus*. Bacteria then travel up through the teat sphincter into the udder, where they cause mastitis. Contagious ecthyma (orf, soremouth) can be easily spread to the teats of a naive ewe from an infected nursing lamb and thence to the hands of the dairymen, where crusts develop and persist for typically 4 or 5 weeks on initial human infection. The milking machine can also spread this virus to additional ewes. Toxic or gangrenous mastitis often results from the scabs on the teats.

If lambs are hungry because the ewe is being asked to raise too many or is not fed properly or because a creep feed is not offered, the lambs may chew on the ewe’s teats. This can cause scab formation and mastitis as described above or painful sores may make machine milking difficult. Bite wounds high on the teat can also result in formation of scar tissue within the teat. The next time the ewe lambs it will not be possible to express milk from the affected teat.

## **Care of the Early Weaned Lamb**

It is common to allow the lambs to nurse for approximately one month in a commercial dairy sheep operation, then to wean them abruptly and milk the ewes in the parlor. The lambs should have had access to a creep feed (preferably with a coccidiostat such as decoquinate or lasalocid) beginning by one week of age. They also need an easily reached palatable and clean water supply. Weaning failure, where the lamb does not drink water or eats only hay after weaning is a common cause of death. Lambs that have been dam reared on pasture may need to be dewormed several weeks after weaning and housing.

The rearing area for weaned lambs needs to be dry, well ventilated, and uncrowded. It is also important that the lambs in a pen vary no more than 2 weeks in age and that the pen be cleaned before younger animals are moved into it. This is for control of coccidiosis, which is otherwise magnified as early born lambs excrete so many oocysts that later born lambs develop diarrhea and illthrift before they can develop immunity. A tight lambing period, obtained by careful attention to the fertility of the ewe and ram, is a major aid in coccidiosis control. Older sick lambs, such as those with chronic pneumonia, should also not be mixed with recently weaned lambs.

An alternative to weaning at a month of age is weaning at 24 hours (after colostrum consumption) and transfer to a lambbar. These lambs need clean dry bedding or an elevated pen with wire flooring. The milk replacer should be one designed for lambs and a starter feed should be offered early on. If coccidiosis is a severe problem, decoquinate can be added to the milk replacer (DeccoxM™), otherwise a coccidiostat should be included in the starter.

## **Biosecurity on the Sheep Farm**

Assembling a dairy flock, purchasing rams or replacement lambs, and showing sheep or showing off the dairy operation to visitors are all very risky ventures. Many diseases of sheep are bought and paid for. Three major chronic diseases with long incubation periods are discussed below, but the owner should not forget about the risks of introducing footrot, pinkeye, soremouth, chlamydial or campylobacter abortions, ram epididymitis, and anthelmintic-resistant parasites. Incoming animals should be quarantined for at least a month, and examined closely for evidence of disease on arrival and at the end of the quarantine period. If possible the newly arrived animals should be managed as a separate group or released into a small subset of the flock for further observation for a year or more.

Trucks should be sanitized before transporting sheep to the farm. Shearing equipment should be sanitized before use, or better yet the flock's own equipment should be used. The flock should not mix with other sheep while on pasture. Visitors should be required to wear disposable boots or boots and coveralls provided by the farm. Animals that leave the farm for a show or exhibition should be quarantined on their return.

## **Caseous Lymphadenitis (CLA)**

Contagious abscesses are caused by the bacterium *Corynebacterium pseudotuberculosis*. The organism has a long incubation period, often of 2 to 6 months or more. Thus it is common to buy animals that have no evidence of the disease, only to find abscesses at the next shearing. Although sheep that only have external abscesses eat and milk normally, the animals that develop abscesses in the lungs and other internal organs commonly develop a wasting disease that leads to death or premature culling. To avoid this risk, buy animals (including rams) only from farms that are believed to be free of caseous lymphadenitis. Additionally, all incoming animals should be palpated for enlargement of external lymphnodes (below the ear, between the lower jaws, in front of the shoulder, on the flank in front of the stifle, at the back of the stifle, and above the udder) on arrival and before release from quarantine. Affordable antibiotics will not successfully resolve these abscesses. Serologic tests currently available are not well validated and furthermore will not distinguish between infected, recovered, and vaccinated sheep.

The infection can be spread by shearing (which opens abscesses and contaminates the blades) or by contact with pus from an abscess that has ruptured spontaneously. Nasal discharges contaminating feed or water will also spread the disease from an animal with lung abscesses. Unthrifty sheep, for whatever reason, should be culled promptly from the flock. If caseous lymphadenitis is already present in the sheep dairy, culling of obviously infected animals and vaccination of replacements will decrease future infections.

## **Ovine Progressive Pneumonia (OPP)**

OPP, referred to in Europe as maedi/visna, is caused by a retrovirus. Viruses of this family (which includes HIV) are never cleared from the infected host. The virus causes a chronic pneumonia in adult sheep, with weight loss, exercise intolerance, and eventually difficulty breathing and death. Many infected ewes live a normal productive life without developing interstitial pneumonia, and the producer may not recognize a major economic loss outside of the occasional young to middle-aged ewe culled as a “lunger”. Some but not all studies have demonstrated a lower milk production in sheep infected with the OPP virus and developing an interstitial mastitis with fibrosis. Arthritis and neurologic disease are less common manifestations of the virus infection.

Sheep infected with the OPP virus are commonly identified by means of a commercial agar gel immunodiffusion (AGID) test. Although the test is specific (animals with a positive test are almost always truly infected), the sensitivity of the test is lower. Thus some animals that carry the virus and can spread it to others in the flock through respiratory secretions, milk, or blood will not produce enough antibodies to give a positive test result. The risk of introducing the virus with a purchased animal will be greatly reduced if the entire source flock has tested negative as opposed to the more dangerous practice of accepting test-negative animals from an infected flock.

Eradication of OPP from a sheep flock has been achieved by testing all ewes before each lambing and promptly culling the seropositive animals. Alternatively, lambs may be removed at birth and fed on cattle colostrum or heat treated sheep or goat colostrum, then milk replacer. A two flock management system is then established, where the artificially reared animals are never allowed to mix with the original, infected flock. Uninfected animals must also be milked before the sheep in the original flock. Serologic testing of the “clean” flock is repeated twice a year for several years, then annually for some years longer if no positive sheep are found.

### **Paratuberculosis (Johne’s Disease)**

Johne’s disease seems to be prevalent in high-producing dairy sheep in this country, partly because source flocks were infected and partly because the disease is more apt to become clinical when sheep are stressed by high production. Sheep over one year of age, and often over two years old lose weight and show decreased production. A small percentage of clinically affected sheep will develop diarrhea, and susceptibility to parasitic infestations is increased. A mild anemia and hypoproteinemia are typical laboratory findings. The causative agent is the bacterium *Mycobacterium paratuberculosis*, more correctly known as *Mycobacterium avium* subspecies. *paratuberculosis*. It can persist in the environment for a year or more.

Sheep strains have traditionally been almost impossible to culture in the laboratory such that diagnosis has depended on demonstration of acid fast staining organisms in histologic sections of intestine or lymph node. Recently the Diagnostic Laboratory at Cornell has acquired new equipment that permits isolation of the sheep strains in just a few weeks. Other laboratory tests allow differentiation of sheep strains from cattle strains of *M. paratuberculosis* and from *Mycobacterium avium*.

Serologic testing is hampered by the late appearance of antibodies to the organism. Even though the young lamb is the most likely animal to become infected, by the fecal-oral route, serum antibodies do not appear until after shedding in the feces has begun, approximately coinciding with the onset of clinical signs. The preferred serologic test for sheep is a small ruminant AGID. ELISA tests designed for cattle, including the recently approved Paracheck™, are not accurate enough in individual sheep to be used alone for diagnosis. Instead they should be used as screening tests and infection of animals with positive ELISA results should be confirmed by fecal culture or necropsy.

If the herd infection status is unknown, serologic and necropsy monitoring should be performed on thin or cull adult sheep. Once the disease has been demonstrated in the flock, management efforts should be directed at limiting fecal oral spread of the agent. This can be accomplished by good feeder design (to keep feet and manure out of the feed), liberal use of bedding, crutching ewes prelambling, avoiding close grazing situations and contaminated water supplies, and timely culling of thin animals and their offspring.

If a dairy sheep flock is to be assembled, seronegative animals should be acquired from flocks that have actively looked for the disease and not found it. Additional biosecurity measures include not grazing lands that have been grazed by infected cattle, sheep, or goats or where

manure from infected flocks has been spread. Trucks should be cleaned and sanitized before use, visitors entering the farm should wear clean boots or disposable foot covering, and colostrum or milk from infected farms should not be fed. Manger sweepings from cattle herds infected with Johne's disease are very apt to spread the infection to sheep, as they do to heifers when fed to youngstock on the cattle dairy.

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# VACCINATION OF EWES AND LAMBS AGAINST PARAINFLUENZA<sup>3</sup> TO PREVENT LAMB PNEUMONIA

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## Introduction

Pneumonia is a major cause of lamb mortality in many sheep flocks and can be a particular problem in artificially-reared lambs in dairy flocks. More than 20% of the non-predator lamb losses reported in the recent National Animal Health Monitoring System sheep survey were due to pneumonia (NAHMS, 2002). While overcrowding, poor ventilation, and inadequate bedding often are contributing factors, lamb pneumonia can be severe even in carefully managed flocks or in flocks kept out of barns. For example, 80% of the lambs in some New Zealand flocks are infected (Goodwin et al., 2002) even though New Zealand lambs rarely see the inside of a barn. Additionally, while Bighorn Sheep live in well-ventilated environments, they are particularly susceptible to pneumonia (Callan et al., 1991; Cassirer et al., 2001; Monello et al., 2001).

Despite the fact that the barn doors are kept open to allow air to be sucked across the pens and up through large fans at the top of the ceilings, many lambs at the Cornell Sheep Farm are treated for pneumonia and it contributes significantly to lamb mortality in the flock. Parainfluenza3 (PI3) is a virus that may contribute to lamb pneumonia by allowing Mannheimia (Pasteurella) haemolytica type A to invade the lung tissue (Cutlip et al., 1993; Martin, 1996). Although there is no sheep vaccine, several companies sell a nasally-administered cattle vaccine against a combination of IBR (Infectious Bovine Rhinotracheitis) and PI3. Some veterinarians have used the PI3 in these vaccines to reduce the incidence of lamb pneumonia (Davies et al., 1980; Davies et al., 1983; Hansen et al., 1995; Lehmkuhl and Cutlip, 1985; Rodger, 1989). The objective of this experiment was to determine if a nasal vaccine against PI3 reduced the incidence of lamb pneumonia in lambs born and housed indoors in the Cornell flock.

## Materials and Methods

The experiment was carried out using 176 Dorset ewes and their 1/4 East Friesian lambs born from 15 March to 8 April 2002. A week before the start of the lambing season when the ewes were given a booster clostridial vaccine (to prevent enterotoxemia and tetanus in lambs by providing antibodies in the colostrum), 90 ewes were vaccinated with 1 mL TSV-2® (Pfizer Inc., Animal Health Group, 235 E. 42nd St., New York, NY 10017). TSV-2® is a modified live bovine rhinotracheitis-parainfluenza3 vaccine administered intranasally. At the time of ear-tagging each litter of lambs within a few days of birth, lambs in alternate litters within vaccinated and control ewe groups received 0.5 mL of TSV-2®. Alternate litters – and not alternate lambs – were vaccinated because there is some evidence that the vaccine can be transferred by close contact.

Lamb health was monitored by recording all treatments and deaths in the Cewe database management system (Thonney, 2002). The data base was interrogated based upon data recorded through 8 October 2002 to determine number of lambs born, lambs born delivered, lambs that died after being born alive, lambs treated for pneumonia, lamb treatments for pneumonia, and lambs that died of pneumonia. Effect of lamb vaccination within ewe vaccination was evaluated by c2.

A subset of 36 male lambs was slaughtered for another experiment at ages ranging from 77 to 161 days. The lungs of those lambs were evaluated for evidence of pneumonia and the effect of lamb vaccination within ewe vaccination was evaluated by c2.

## Results and Discussion

Of the 306 lambs in this experiment, 20 lambs were delivered dead for a stillborn death loss of 6.5% (Table 1). The live lambing rate was 1.6 per ewe. Lambs were all weaned by 70 days after the start of the 24-day lambing season when the youngest lambs were 46 days old.

The first lamb was sold at 66 days of age (Figure 1). Therefore, the data were analyzed in two groups. The first group included records from birth to 66 days of age. The second group included records from birth to 183 days of age because the youngest lamb was 183 days old on 8 October 2002 when the data base was interrogated. Sixty-four of the 286 lambs born alive had been sold by this date so the analysis for the second group assumed that lambs sold would not have been treated or died at a later date.

Table 1. Number of lambs born, treated lambs, lamb treatments, and lambs dying to 66 days of age.

Vaccination	Ewes	Lambs	Lambs	Lambs	Lambs	Lamb	Lambs that
Ewe Lamb	lambing	delivered	born alive	that died	treated for	treatments for	died of
		(per ewe)	(per ewe)	(% died <sup>a</sup> )	(% treated <sup>a</sup> )	(per lamb <sup>a</sup> )	pneumonia
Yes	Yes	45	78 (1.7)	73 (1.6)	7 (9.0)	6 (8.2)	8 (0.11)
	No	45	79 (1.8)	76 (1.7)	6 (7.6)	5 (6.6)	10 (0.13)
No	Yes	43	70 (1.6)	62 (1.4)	4 (6.4)	2 (3.2)	4 (0.06)
	No	43	79 (1.8)	75 (1.7)	11 (14.7)	4 (5.3)	9 (0.12)
Total		176	306 (1.7)	286 (1.6)	28 (9.7)	20 (5.9)	31 (0.11)
							10 (3.5)

<sup>a</sup>Of those born alive.

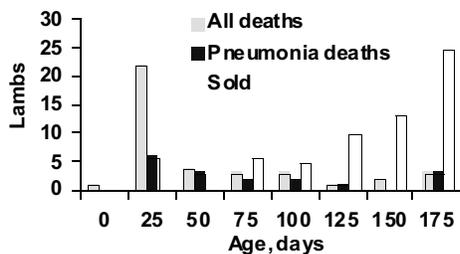


Figure 1. Distribution of ages of dead and sold lambs.

Twenty-eight, or 9.7% of lambs born alive died before they were 66 days old (Table 1, Figure 1) and 39, or 13.6% died before they were 183 days old (Table 2). Weaning in most flocks occurs within the range of 66 to 183 days of age. Previously published losses to weaning of lambs born alive in closely-managed research flocks ranged from 9.4 to 24.4%

(Table 3). Losses generally were higher in more prolific breeds. Thus, lamb losses in the present experiment were not excessive. However, pneumonia caused the deaths to 66 days of age of 3.5% and to 183 days of age of 6.3% of lambs born alive. These represented 36 and 46% of the lamb losses, respectively.

Table 2. Treated lambs, lamb treatments and number of lambs dying to 183 days of age.

Vaccination		Lambs that died	Lambs treated for pneumonia	Lamb treatments for pneumonia	Lambs that died of pneumonia
Ewe	Lamb	(% died <sup>a</sup> )	(% treated <sup>a</sup> )	(per lamb <sup>a</sup> )	(% died <sup>a</sup> )
Yes	Yes	8 (11.0)	6 (8.2)	8 (0.11)	3 (4.1)
	No	9 (11.8)	7 (9.2)	12 (0.16)	5 (6.6)
No	Yes	9 (14.5)	3 (4.8)	5 (0.08)	6 (9.7)
	No	13 (17.3)	5 (6.7)	11 (0.15)	4 (5.3)
Total		39 (13.6)	21 (7.3)	36 (0.13)	18 (6.3)

<sup>a</sup>Of those born alive.

Within ewe vaccination groups, there was no significant effect of lamb vaccination on any of the counts of lamb mortality (Tables 1 and 2). From 9 to 14.7% of lambs born alive died to 66 days of age and from 11.0 to 17.3% of lambs born alive died to 183 days of age in each of the four ewe-vaccination, lamb vaccination groups. From 3.2 to 8.2% of lambs were treated for pneumonia to 66 days of age and from 4.8 to 9.2% of lambs were treated for pneumonia to 183 days of age. Neither the number of lambs treated nor the number of treatments were significantly affected by lamb vaccination within ewe vaccination groups. Within the vaccinated ewe group, 4.1% of vaccinated lambs and 3.9% of control lambs died of pneumonia to 66 days of age while 4.1% of vaccinated lambs and 6.6% of control lambs died of pneumonia to 183 days of age. Within control ewes, vaccinated lambs had a slightly higher death rate from pneumonia than control lambs. Thus, vaccination with PI3 did not reduce the incidence of treatments or deaths due to pneumonia.

Table 3. Lamb death losses reported in the literature in closely-managed research flocks.

Reference	Breed	Death loss of lambs born alive	Lambs born alive per ewe lambing
(Johnston et al., 1999)	Greyface, Suffolk-Cheviot	9.4%	1.5
(Wassmuth et al., 2002)	Rhönshaf, German Blackface	10.3%	1.2
(Oltenacu and Boylan, 1981)	Finnsheep, Minnesota 100, Suffolk, Targhee	14.9%	1.6
(Matos et al., 2000)	Rambouillet, Finnsheep	21.4% <sup>a</sup>	2.0 <sup>a</sup>
(Hulet et al., 1984)	Polypay	22.9% <sup>b</sup>	1.4 <sup>b</sup>
(Carson et al., 2002)	Texel, Rouge de l'Ouest	24.4%	1.8

<sup>a</sup>Includes lambs born dead.

<sup>b</sup>May include lambs born dead.

Table 4. Numbers of lambs dying from causes other than pneumonia.

Vaccination		Other causes of death	Age from birth	
Ewe	Lamb		66 days	183 days
-----lambs (% dead of lambs born alive)-----				
Yes	Yes	Omphalitis	1 (1.4)	1 (1.4)
		Starvation <sup>a</sup>	1 (1.4)	1 (1.4)
		Unknown	2 (2.7)	2 (2.7)
		Urolithiasis	0 (0.0)	1 (1.4)
	No	Grain overload	1 (1.3)	1 (1.3)
		Hypothermia	1 (1.3)	1 (1.3)
		Listeriosis	0 (0.0)	1 (1.3)
		Unknown	1 (1.3)	1 (1.3)
No	Yes	Arthritis	0 (0.0)	1 (1.6)
		Starvation <sup>a</sup>	2 (3.2)	2 (3.2)
	No	Birth defect	1 (1.3)	1 (1.3)
		Pyelonephritis	1 (1.3)	1 (1.3)
		Starvation <sup>a</sup>	3 (4.0)	3 (4.0)
		Unknown	4 (5.3)	4 (5.3)

<sup>a</sup>Starvation was diagnosed if the lamb had no obvious fat tissue and no milk in the stomach.

Table 5. Lambs dying of pneumonia or of unknown causes.

Vaccination		Deaths <sup>a</sup> (% died)	
Ewe	Lamb	to 66 days	to 183 days
Yes	Yes	5 (6.8)	5 (6.8)
	No	6 (7.9)	6 (7.9)
No	Yes	2 (3.2)	6 (9.7)
	No	5 (6.7)	8 (10.7)

<sup>a</sup>Of those born alive.

The other lambs died of arthritis, birth defect, grain overload, hypothermia, listeriosis, omphalitis, starvation, urolithiasis, or unknown causes (Table 4). A determination of cause of death was attempted by necropsy of all dead lambs, but sometimes no necropsy could be done or no cause of death could be determined. For that reason, the number of lambs dying of unknown causes was added to the number known to have died from pneumonia (Table 5). Still, there was no meaningful effect of vaccination on lamb deaths in this experiment.

Table 6. Incidence of pneumonia in 34 slaughtered male lambs.

Vaccination		Slaughtered lambs	Evidence of pneumonia
Ewe	Lamb		
Yes	Yes	8	8
	No	14	8
No	Yes	6	6
	No	6	5

Data from the subset of 34 male lambs that were slaughtered for another experiment at ages from 77 and 161 days are shown in Table 6. Only one lamb – in the vaccinated ewe, control lamb group – had been treated for pneumonia, and it was 15 to 20 days of age at the time of treatment. None of the lambs showed clinical signs of pneumonia just prior to slaughter. All of the lambs that were vaccinated – regardless of whether their dams were vaccinated – had evidence in their lungs of

having had pneumonia. Eight of 14 control lambs from vaccinated ewes ( $P < 0.03$ ) and 5 of 6 control lambs from control ewes had evidence in their lungs of having had pneumonia. Thus, while only about 6% of the lambs born alive died from pneumonia (Table 2), based upon the data in Table 6 it is likely that more than 75% of all other lambs had pneumonia and that most of those went undetected. Furthermore, vaccination with PI3 was ineffective in preventing sub-clinical or clinical pneumonia in this experiment.

### Conclusions

Lamb death losses in the Cornell Dorset flock are within the range of those reported for other research flocks and pneumonia is a major cause of those losses. Vaccination with PI3 did not change the incidence of pneumonia in 286 lambs born alive from 176 ewes. Perhaps the virus was not a factor for inducing pneumonia in this flock. Other vaccines or methods need to be developed to control lamb pneumonia. There is evidence from the Ohio Experiment Station more than 30 years ago that, in flocks with high levels of pneumonia, lambs may be infected orally via absorption of *Mannheimia* (*Pasteurella*) *haemolytica* shortly after birth through the gut wall followed by transmittal to the lungs (Smith et al., 1969). Sulfamethazine treatment of ewes prior to lambing prevented lamb pneumonia in the Ohio studies (Smith et al., 1969; Smith et al., 1970; Smith et al., 1971). This is now an off-label use for sulfamethazine, however, and requires a veterinary prescription and a significant withdrawal time to ensure that no residue remains in animal tissues or milk destined for human consumption. The best approach would be to develop a sheep vaccine against several of the organisms known to cause pneumonia in lambs so that ewes could be vaccinated prior to lambing. Like vaccination to prevent enterotoxemia (de la Rosa et al., 1997), this would provide protection against lamb pneumonia through colostrum.

### Acknowledgements

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# THE EFFECT OF IBR/PI3 AND *PASTEURELLA* VACCINATION ON THE MORTALITY RATE OF HIGH PERCENTAGE EAST FRIESIAN LAMBS

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## Background

The United States does not have a history of sheep dairying, and, as a consequence, much effort has been devoted to the importation of European dairy sheep breeds such as the East Friesian. Previous research at the Spooner Agricultural Research Station has shown that milk production, lactation length, ewe prolificacy, and lamb growth rates of domestic breeds such as the Dorset, Rambouillet, and Polypay are improved when these breeds are crossed with the East Friesian (Thomas et al., 1998 and 2000). However, at this same location we have reported a significant and undesirable positive relationship between percentage of East Friesian breeding and lamb mortality (Thomas et al., 1999 and 2000). In the 1999 lamb crop, lambs of over 50% East Friesian breeding had a mortality rate of 28% compared to mortality rates ranging from 12% to 4% for groups of lambs with from 50% to 0% East Friesian breeding (Thomas et al., 1999 and 2000). In the 2000 lamb crop, lambs with the highest proportion of East Friesian breeding (over 75% East Friesian breeding) had a 48% mortality rate; the highest rate for any breed group (Thomas and Berger, unpublished data).

Increased mortality of high percentage East Friesian has been reported previously. Katsaounis and Zygoyiannis (1986) reported especially poor viability of East Friesian sheep in Greece. They imported a total of 52 ewes, 10 rams and 18 lambs of East Friesian breeding in the three years of 1956, 1960, and 1965. They were run on their experimental farm along with sheep of two local dairy breeds. Of these imported animals, all the lambs died within two months, and all the adults had died by 1970. Of the East Friesian lambs born in the flock in Greece, 38.3% were stillborn or not viable at birth, 29.6% died before the age of two months, and of those weaned, 69.2% died before one year of age. Ewes of 1/2 East Friesian breeding lived for a respectable 5.1 years (similar to the local breeds). However, ewes of higher percentages of East Friesian breeding had very short lifespans: 3/4 East Friesian = 2.6 years, 7/8 East Friesian = 2.7 years, 15/16 East Friesian = 2.5 years, 31/32 East Friesian = 2.5 years, and pure East Friesian = 2.0 years. The most common cause of death among lambs was pneumonia with a high incidence of Maedi (OPP-like disease) in adult ewes.

Ricordeau and Flamant (1969) also reported an increased death loss to respiratory disease of East Friesian-cross lambs in France. In different years and with percentages of East Friesian breeding varying from 50% to 87.5%, they reported a 2.2% to 22.2% increased death loss in East Friesian-cross lambs from pasteurellosis and pneumonia compared to Préalpes du Sud lambs.

We were aware of previous problems with high mortality of East Friesian lambs in Mediterranean countries but thought this may have been due to the fact that the environment in these countries is considerably different from the northern European environment where the East Friesian breed was developed. Since the environment in northern Wisconsin is more similar to the environment of northern Europe than is the Mediterranean region, we expected less mortality problems here. This was not the case.

Over 63% of lamb death losses in 1999 were attributed to pneumonia (Thomas et al., 1999 and 2000). Lambs typically presented a marked respiratory disease and died within 2 to 3 days of clinical onset. Histopathology revealed classic findings of bronchopneumonia, and in some cases, focal abscessation. Bacteriological culture revealed *Pasteurella haemolytica* and *multocida*.

While it was desirable to discover that the East Friesian breed may have increased susceptibility to respiratory disease in the temperate environment of northern Wisconsin, it is now necessary to determine if there are health programs that can prevent this disease. Dairy sheep producers in North America have few breed options. The only other dairy sheep breed available to North American dairy sheep producers is the French Lacaune. The Lacaune is available in only limited numbers, and a comprehensive comparison of the Lacaune and East Friesian breeds has not been completed.

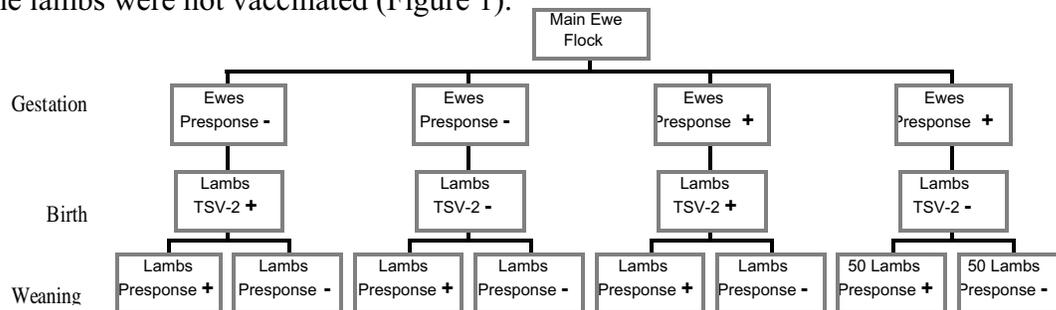
The objective of the present experiment is to evaluate the efficacy of vaccinating the ewes and/or their lambs with one or two commercial vaccines on the incidence of lamb mortality.

## **MATERIALS AND METHODS**

**Animals.** The study was conducted with the 2001 lamb crop from the dairy flock at the Spooner Agricultural Research Station. Ewes and lambs were various percentages of East Friesian, Lacaune, Dorset, Rambouillet, and/or Polypay breeding. Many animals also contained a very small percentage of Targhee and Finnsheep or Romanov breeding. Proportion of East Friesian breeding in the lambs varied from 0% to over 94%. Lambing occurred from February 6 through May 21, 2001. A total of 527 lambs were born. Lambs were either raised on milk replacer from shortly after birth or by their dams in drylot until weaned at approximately 30 days of age. Prior to weaning, lambs had free access to a high energy creep diet. After weaning, lambs were fed high energy diets in drylot until marketed or selected as a replacement.

**Treatments.** Prior to lambing, ewes were randomly assigned to one of two gestational treatments within ewe age and proportion of East Friesian breeding (Figure 1): approximately 1/3 of the ewes were vaccinated with 2 ml of a bacterial toxoid preparation of *Pasteurella haemolytica/multocida* (Presponse HM<sup>®</sup>, Fort Dodge Animal Health, Inc.) at 8 and 4 wk prior to parturition; the other 2/3 of the ewes were not vaccinated. At lambing, all lambs born to an individual ewe received one of two birth treatments (Figure 1): within ewe vaccination treatments, approximately 1/3 of the lambs were vaccinated with 0.5 ml of a modified live preparation of IBR and

PI<sub>3</sub> viruses (TSV-2<sup>®</sup>, SmithKline Beecham Animal Health) in each nares, the other 2/3 of the lambs received no intranasal vaccine. At weaning, slightly less than 1/2 of the lambs within each ‘ewe vaccination/lamb birth vaccination’ group were vaccinated with 2 ml of a bacterial toxoid preparation of *Pasteurella haemolytica/multocida* (Presponse HM<sup>®</sup>), and slightly more than 1/2 of the lambs were not vaccinated (Figure 1).



**Figure 1.** Experimental treatment combinations for the dairy ewe flock and their lambs at the Spooner Agricultural Research Station during the gestation/lactation 2000-2001. Presponse = bacterial toxoid preparation of *Pasteurella haemolytica/multocida*. TSV-2 = modified live preparation of IBR and PI<sub>3</sub> viruses.

**Mortalities.** Lamb mortality was determined from birth until approximately 7 months of age, but no mortalities occurred after August 20, 2001. Lambs that were born dead or that died within 1 day of birth were deleted from the study. Of the 527 lambs born, 499 were living 1 day after birth. Eighteen of the 499 lambs (3.6%) died prior to weaning. Of the 481 lambs weaned, 37 lambs (7.7%) died postweaning. Of the 527 lambs born, 83 died by August 20, 2001 for an overall mortality rate of 15.7%. Of the 499 lambs alive 1 day after birth, 55 died (11.0%). Of these 55 dead lambs, 27 died from pneumonia (7 preweaning and 20 postweaning) and 28 died from other causes (11 preweaning and 17 postweaning).

**Statistical analyses.** Data were analyzed with the General Linear Models Procedure of SAS. Lambs were recorded a 1 if they survived and a 0 if they died. The model for data set with all lambs treated at birth included the effects of proportion of East Friesian breeding (0-49%, 50-74%, or 75-100%), dam age (1 year or 2 years and older), lamb sex (male, female), ewe vaccination (yes or no), lamb birth vaccination (yes or no), and significant two-way interactions. The same model was used for the data set with all lambs surviving to weaning with the addition of lamb weaning vaccination (yes or no). Birth type of lamb (single or multiple) initially was fit to each model. Since birth type was never significant and there were few single-born lambs, birth type was deleted from both models. The numbers of lambs in each data set are presented in Tables 1 and 2.

Table 1. Number of lambs treated at birth by breed group and ewe vaccination treatment

% East Friesian breeding of lamb	Ewe vaccination treatment				Total by breed group
	No Pasteurella		Pasteurella		
	Lamb vaccination treatment at birth				
	No IBR/PI <sub>3</sub>	IBR/PI <sub>3</sub>	No IBR/PI <sub>3</sub>	IBR/PI <sub>3</sub>	
0 – 49 %	129	83	63	43	318
50 – 74 %	41	15	15	11	82
75 – 100 %	43	24	20	12	99
Total by vaccination	213	122	98	66	499

Table 2. Number of lambs treated at weaning by ewe vaccination and lamb birth vaccination treatments

Lamb weaning vaccination	Ewe vaccination treatment				Total by weaning trt.
	No Pasteurella		Pasteurella		
	Lamb vaccination treatment at birth				
	No IBR/PI <sub>3</sub>	IBR/PI <sub>3</sub>	No IBR/PI <sub>3</sub>	IBR/PI <sub>3</sub>	
No Pasteurella	122	61	47	34	264
Pasteurella	85	56	47	29	217
Total by birth trt.	207	117	94	63	481

## Results

**Prewaning mortality.** The effects of several factors on preweaning survival of lambs treated at birth are presented in Table 3. No factors influenced preweaning lamb survival including ewe vaccination with *Pasteurella* and lamb vaccination at birth with IBR/PI<sub>3</sub>. There were three significant two-way interactions among the factors, but in all cases every sub-group of lambs had a preweaning survival rate of 90% or greater. Biological reasons for the existence of the interactions were not evident.

Table 3. Prewaning lamb survival (%) of lambs alive at birth as affected by various factors

Factor	No. of lambs	Mean $\pm$ standard error
% East Friesian breeding:		
0 – 49 %	318	93.4 $\pm$ 1.2
50 – 74 %	82	97.2 $\pm$ 2.3
75 – 100 %	99	94.8 $\pm$ 2.0
Dam age:		
1 year	224	94.7 $\pm$ 1.5
2 or more years	275	95.5 $\pm$ 1.7
Lamb sex		
Female	260	94.5 $\pm$ 1.4
Male	239	95.8 $\pm$ 1.4
Ewe vaccination		
No <i>Pasteurella</i>	335	95.5 $\pm$ 1.3
<i>Pasteurella</i>	164	94.8 $\pm$ 1.6
Lamb vaccination at birth		
No IBR/PI <sub>3</sub>	311	94.8 $\pm$ 1.4
IBR/PI <sub>3</sub>	188	95.5 $\pm$ 1.7

It is very difficult to show an effect of vaccination when non-vaccinated animals had a survival rate of 95%. It is possible that the presence of vaccinated ewes and lambs reduced the incidence of infectious agents to the point where non-vaccinated animals were not exposed to high enough levels to cause disease.

**Postweaning mortality.** Lambs that survived weaning were either vaccinated or not vaccinated for *Pasteurella*. Presented in Table 4 are the effects of various factors on postweaning lamb survival. Lambs from 1-year-old dams had lower ( $P < .05$ ) postweaning survival than lambs from dams 2 years of age and older, and male lambs had lower ( $P < .05$ ) postweaning lamb survival than female lambs. Vaccination of ewes with *Pasteurella* and lambs at birth with IBR/PI<sub>3</sub> had no significant effect on postweaning lamb survival.

Table 4. Postweaning lamb survival (%) of lambs alive at weaning as affected by various factors

Factor	No. of lambs	Mean $\pm$ standard error
Dam age:		
1 year	214	84.6 $\pm$ 2.1 <sup>b</sup>
2 or more years	267	96.2 $\pm$ 2.1 <sup>a</sup>
Lamb sex		
Female	249	92.9 $\pm$ 2.0 <sup>a</sup>
Male	232	88.0 $\pm$ 2.0 <sup>b</sup>
Ewe vaccination		
No Pasteurella	324	90.3 $\pm$ 1.8
Pasteurella	157	90.5 $\pm$ 2.3
Lamb vaccination at birth		
No IBR/PI <sub>3</sub>	301	89.3 $\pm$ 1.9
IBR/PI <sub>3</sub>	180	91.6 $\pm$ 2.3

<sup>a,b</sup> Means within a factor without a common superscript are different ( $P < .05$ ).

There was a significant interaction between proportion of East Friesian breeding and lamb Pasteurella vaccination at weaning on postweaning lamb survival. Among the two breed groups with the lowest proportion of East Friesian breeding, there were no significant differences for postweaning survival between vaccinated and non-vaccinated lambs. However, within the group of lambs of 75% or greater East Friesian breeding, vaccinated lambs had a greater ( $P < .05$ ) postweaning survival than did non-vaccinated lambs (94.4 vs. 79.6 %).

It appears that lambs in 2001 were under greater risk of death postweaning than preweaning because twice as many lambs died after weaning as before (of lambs living more than 1 day). It also appears that the lambs of very high percentage East Friesian breeding are at greater risk of death postweaning than lambs of a lower percentage East Friesian breeding. These data suggest that during periods of greater risk and with genotypes of greater risk, vaccination of lambs for Pasteurella may result in reduced lamb mortality. Since the number of lambs of high percentage East Friesian breeding included in this study was relatively small, further work should be done with larger numbers of animals to clarify this situation.

Table 5. Interaction between lamb breeding and lamb Pasteurella vaccination at weaning on postweaning lamb survival

% East Friesian breeding of lamb	Lamb Pasteurella vaccination treatment			
	No Pasteurella		Pasteurella	
	No.	Mean $\pm$ se, %	No.	Mean $\pm$ se, %
0 – 49 %	165	90.5 $\pm$ 2.2 <sup>a</sup>	140	92.8 $\pm$ 2.4 <sup>a</sup>
50 – 74 %	59	98.0 $\pm$ 3.6 <sup>a</sup>	22	87.3 $\pm$ 5.7 <sup>a,b</sup>
75 – 100 %	40	79.6 $\pm$ 4.3 <sup>b</sup>	55	94.4 $\pm$ 3.6 <sup>a</sup>

<sup>a,b</sup> Means without a common superscript are different ( $P < .05$ ).

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## GENETIC IMPROVEMENT PROGRAM FOR DAIRY SHEEP

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Dairy sheep industry is very developed in Europe, especially in Mediterranean area where there is a strong tradition for dairy sheep farming. By comparison, the dairy sheep industry in North America is much smaller and certainly much younger but it has been growing and there are substantial opportunities for future growth.

A genetic improvement program for milk yield and composition as well as meat production in dairy sheep is an important component toward the development of a viable industry. To remain competitive, the industry needs to increase its productivity and a genetic program is the only alternative it has for improving the biological efficiency of producing milk for cheese and lambs for meat.

Milk production is a quantitative trait, i.e., controlled by a large number of genes. The genetic parameters for the milk traits in dairy sheep for Lacaune breed (F. Barillet and D. Boichard, 1987, *Genet. Sel. Evol.*, 19:459-474) are shown in Table 1. Note that they are very similar with the genetic parameters of milk traits in dairy cattle. It is ver

Table 1. Genetic parameters for milk traits in Lacaune breed (France). Heritabilities on the diagonal and genetic correlations below diagonal.

Trait	Milk Yield	Fat Yield	Prot. Yield	Fat %	Protein %
Milk Yield	<b>0.30</b>				
Fat Yield	0.83	<b>0.28</b>			
Prot. Yield	0.91	0.89	<b>0.29</b>		
Fat %	-0.31	0.26	-0.06	<b>0.35</b>	
Protein %	-0.40	-0.04	-0.03	0.65	<b>0.46</b>

A breeding strategy to improve dairy traits may involve either crossbreeding or within purebred selection programs. The method most generally used in Europe for genetic improvement is purebred selection. Though some crossbreeding is also used, the crossbreeding programs implemented are very simple schemes which involve upgrading of a local population by an established dairy sheep breed.

The genetic programs implemented for several European breeds (Lacaune and Manech in France, Sarda and Comisana in Italy) are similar to those in dairy cattle, but adapted to the biological and management characteristics of the population of dairy sheep for which the programs were designed.

These programs involves progeny testing of young rams in milk recorded flocks, selection of best rams and their use in elite matings to product superior breeding rams. In general, a genetic pyramidal structure is developed in the population served by the program, with an open selection nucleus at the apex of the pyramid, where genetic progress is generated, and a mechanism to disseminate the genetic progress generated in the nucleus throughout the entire population. Genetic improvement is disseminated from the nucleus flocks to the rest of the population via the sale of breeding rams or via AI.

Among the major obstacles that need to be overcome are the fragmented nature of the population with essentially no genetic ties between flocks, inadequate production recording system, and use of AI.

Effective genetic programs have been implemented and North American dairy sheep industry should carefully evaluate existing programs and develop and implement a program to serve the industry.

The principal steps in the development of a program are:

1. Specify the direction of the program. It involve the goal definition and a description of the desirable characteristics of the end product. This is very important and the breeders should spend considerable effort to define objective goals, keeping in mind that, at least during the initial phases of the program, the focus should be on tangible goals.
2. Choose a production methods. For dairy sheep most likely should be purebred selection. Though crossbreeding is often mentioned, we should rememebr that a cross breeding program requires a strong poorebred programs for all breeds involved in the crossbreeding.
3. Specify the records to be kept. Efficiency is critical.
4. Define selection criteria for choosing parents. For dairy sheep, the preferable criteria are progeny teting for rams and own performance combined with information from relatives for ewes.

It should be kept in mind that an efficient genetic improvement program must not only generate genetic gain but also ensure its difussion to the entire population. What is needed is a program that serves an entire population and not only a few breeders.

# MILK COMPOSITION AND CHEESE YIELD

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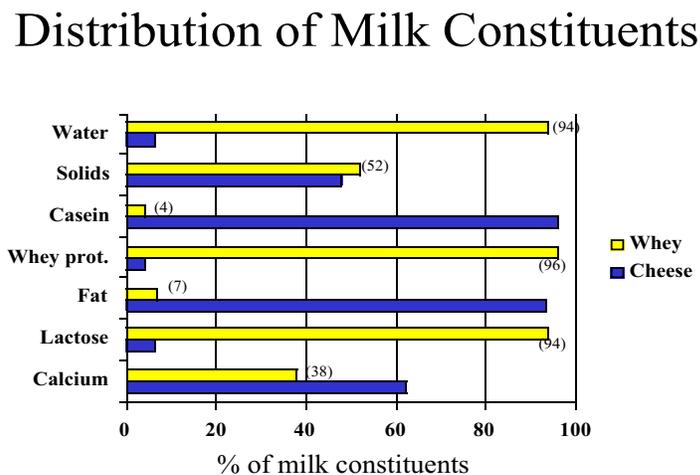
## Introduction

Since milk costs represent approximately 85% of the cost of producing cheese, it is only fitting that we take a close look at milk composition and how much cheese we get from a specific source of milk. Cheese is a product in which the protein and fat of the milk are concentrated, so it is clear that cheese yield is related to casein and fat content of the milk (1).

When the Wisconsin dairy sheep industry got started in the mid 1990s, cheesemakers had to get accustomed to a whole new source of milk. All were familiar with cow milk and some were familiar with goat milk. However, sheep milk was much more concentrated with about twice as much fat and 40% more protein than cow or goat milk. They also found that sheep milk responded differently in the cheese make procedure. It was more sensitive to rennet, coagulated faster, produced a firmer curd and yielded more cheese per unit of milk than cow milk. Our objective of this report is to review factors impacting sheep milk composition and the resulting impact on cheese yields obtained from sheep milk.

Figure 1 shows what the distribution of milk constituents are in the cheesemaking process. About 96% of the casein, 93% of the milkfat, and 60% of the calcium will be retained in the curd of Cheddar cheese. The majority of the whey proteins, lactose and water are separated out in the form of whey. Since the moisture portion of cheese is actually whey, we do retain small amounts of whey proteins and lactose in the final cheese, proportionate to the moisture content. However, it is obvious that the fat and casein content of the milk will be the key constituents of milk that will contribute the most towards the yield of cheese. With that in mind, let's look at some of the factors that impact sheep milk composition and how those may impact cheese yield:

Figure 1. Distribution of milk components in Cheddar cheese.



## Breed of sheep

Alichanidis and Polychroniadou (2) have reported milk composition for a number of European and Asian breeds (Table 1). Milkfat ranges from 5.33% for Nadjii to 9.05% for Vlahico ewes. Milk protein ranges from 4.75% to 6.52%. Jordan and Boylan (3) reported milk composition for some of the domestic sheep breeds in the U.S. that were bred more for market lambs (Table 2). Some of the earlier producers in Wisconsin started milking operations with Dorset ewes that produced high solids milk. At the present, most producers are including some dairy genetics in their flock in the form of East Friesian or Lacaune sheep. These breeds tend to produce more milk per lactation but with lower solids.

**Table 1.** Milk composition of various European and Asian breeds of dairy sheep.

<i>Breed</i>	<i>Fat, %</i>	<i>Protein, %</i>	<i>Lactose, %</i>	<i>Total solids, %</i>
Lacaune	7.40	5.63	4.66	----
Boutsico	7.68	6.04	4.80	19.30
Vlahico	9.05	6.52	----	20.61
Karagouniko	6.43	5.97	4.95	18.15
Nadjii	5.33	4.75	4.48	15.42
Friesland	7.30	5.82	4.37	18.46
Merino-Balbass	5.84	5.29	4.69	16.89

Ref.: Alichanidis & Polychroniadou, 1999.

**Table 2.** Milk composition of various domestic breeds of sheep.

<i>Breed</i>	<i>Fat, %</i>	<i>Protein, %</i>	<i>Lactose, %</i>	<i>Total solids, %</i>
Suffolk	6.8	6.2	4.8	18.5
Targhee	6.5	6.1	4.8	18.1
Finn	5.7	5.7	4.8	16.8
Dorset	6.7	6.5	4.8	18.3
Lincoln	6.5	6.1	4.8	17.3
Rambouillet	7.0	6.2	4.9	18.7

Ref.: Jordan & Boylan, 1995.

## Season or lactation

Several researchers (4,5) have reported on seasonal changes in milk composition of dairy sheep. Both fat and protein tend to increase throughout the lactation (Table 3). This would typically result in higher cheese yields in late lactation milk. However, as shown in Table 4, fat increases at a disproportionate level to casein in late lactation so that the C/F ratio decreases throughout the lactation (6). This will impact the type of cheeses that might be produced throughout the season unless milk is standardized by removing some of the excess milkfat from late lactation milk. If milk is not standardized, fat losses in the whey will increase toward the latter part of the lactation and cheese yields will decrease.

**Table 3.** Effect of season on composition of sheep milk.

<i>Component</i>	<i>Early</i>	<i>Midseason</i>	<i>Late</i>
Fat, % <sup>a</sup>	6.26	6.50	7.82
Protein, % <sup>a</sup>	4.98	5.36	5.61
Fat, % <sup>b</sup>	3.6	7.3	8.8
Protein, % <sup>b</sup>	5.1	5.4	6.3

Ref.: <sup>a</sup> Barron, et al., 2001.

<sup>b</sup> Requena, et al., 1999.

**Table 4.** Effect of season on composition of Lacaune sheep milk.

<i>Component</i>	<i>48-55 days</i>	<i>132-139 days</i>	<i>174-192 days</i>
Fat, %	6.05	7.89	8.33
Protein, %	4.91	6.20	6.21
Casein, %	3.70	4.78	4.74
C/TP, %	80.1	80.4	80.1
C/F ratio	.611	.606	.569

Ref.: Pellegrini, et al., 1997.

### Management systems

In 1999, UW researchers (7) reported on the effects of three different weaning and rearing systems on milk production and lamb growth. The three systems consisted of weaning at day 1 (DY 1), separating lambs for 15 hr from late afternoon till morning and machine milking once daily in the morning (MIX), and weaning at 30 days (DY30). After 30 days all three groups were milked twice per day. Table 5 shows the fat and protein content of milk for each of these systems throughout the lactation. As usual, fat levels increased throughout the lactation. However, protein levels decreased through the lactation for the DY1 and MIX ewes. During the first 30 days, the MIX ewes produced milk with abnormally low levels of milkfat. We are currently evaluating the cheese yielding potential of milk from DY1 and MIX ewes to determine the quality of the milkfat in the reduced-fat MIX milk (8). Milk compositions of these two milk supplies are shown in Table 6. MIX milk was extremely depressed in milkfat to the point that the milk had a C/F ratio of 1.59 while the DY1 milk was more typical at a C/F ratio of .70. McKusik et al. (7) report that milkfat was depressed in the MIX milk due to impairment of the milk-ejection reflex and retention of larger fat globules in the udder. Our study is designed to determine if the milkfat composition of the MIX milk is uniquely different from DY1 and more traditional sheep milk supplies.

**Table 5.** Effect of management systems on composition of sheep milk.

		<i>DY1</i>	<i>MIX</i>	<i>DY30</i>
Fat, %	Pre-wean	4.88	3.24	
	Peri-wean	4.90	4.78	4.21
	Post-wean	5.14	5.25	5.30
Protein, %	Pre-wean	5.52	5.36	
	Peri-wean	5.12	5.04	5.07
	Post-wean	5.07	5.11	5.30

Ref.: McKusick, et al., 1999.

**Table 6.** Milk composition of different management system ewes in cheesemaking trials.

<i>Component</i>	<i>DY1</i>	<i>MIX</i>	<i>DY30</i>
Fat, %	6.78	2.72	4.68
Protein, %	6.13	5.51	5.75
Casein, %	4.75	4.32	4.50
C/TP, %	77.0	78.0	78.0
C/F ratio	.70	1.59	.96

Ref.: Jaeggi, et al., 2002.

### Milk quality

The somatic cell count (SCC) of milk is representative of the health of the udder and can be an indicator of the potential presence of mastitis. As the SCC increases in the milk supply, the composition of milk also changes. Table 7 shows the results of a study that was reported at the 6<sup>th</sup> Great Lakes Dairy Sheep Symposium in Canada (9). As SCC increased, milkfat and the C/TP ratio decreased. Protein recovery rate was lower in the high SCC milk while cheese yield was not significantly different. In a study that we reported on last year (10), The C/TP ratio decreased with increasing SCC but fat and protein were somewhat variable (Table 8). The cheese yield dropped from 16.03% down to 15.09% with an increase in SCC. Lower cheese yields were attributed to lower casein and fat contents of the higher SCC milk. Cheese graders also noted increased levels of rancidity in the higher SCC cheese. No major differences were noted in cheese texture between the different levels of SCC.

**Table 7.** Effect of SCC on milk composition in Italy.

<i>Component</i>	<i>SCC &lt; 500,000</i>	<i>500T – 1 M</i>	<i>1 M – 2 M</i>
Fat, %	6.61	6.34	6.36
Tr. Protein, %	5.25	5.45	5.51
Casein, %	4.18	4.26	4.20
C/TP, %	79.7	78.2	76.3
C/F ratio	.632	.672	.660

Ref.: Pirisi, et al., 2000.

**Table 8.** Effect of SCC on milk composition in Wisconsin.

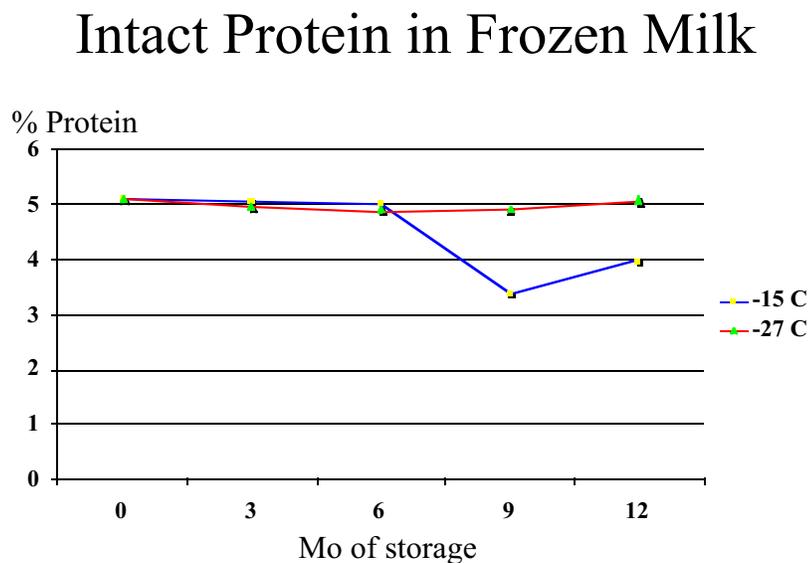
<i>Component</i>	<i>&lt;100T</i>	<i>100T – 1 Mil.</i>	<i>&gt; 1 Million</i>
Fat, %	5.49	5.67	4.86
Protein, %	5.23	5.31	5.02
Casein, %	3.99	3.97	3.72
C/TP, %	76.3	74.8	74.0
C/F ratio	.73	.70	.77

Ref.: Jaeggi, et.al., 2001.

### Milk storage

Last year we reported on the studies we conducted on the stability of frozen sheep milk (11,12). In 1997, several of our cheesemakers experienced problems with destabilized casein in sheep milk that had been frozen and stored in home freezers. The destabilized casein would not react in the coagulation process and there was significant loss in cheese yield from that frozen milk. Cheesemakers also experienced a significant increase in occurrence of rancid flavors in the home-freezer frozen milk. When we compared milk that was frozen and stored in home freezers versus commercial freezers, we found that after 6 months of storage at -15°C (5°F), casein destabilization was experienced (Fig. 2). At 9 months of storage, we experienced over 40% destabilization of the casein. The primary cause for destabilization of the casein was the high concentration of calcium in sheep milk. Based on our study, we recommend fast freezing of the sheep milk and storage at -27°C or lower for up to 12 months. If freezing in a home freezer (-12°C), limit storage of the frozen milk to 3 months maximum.

**Figure 2.** Effect of protein stability in frozen sheep milk.



## Nutrition of the ewe

At the 5<sup>th</sup> Great Lakes Dairy Sheep Symposium, Spanish researchers reported on the effect on nutrition on ewe's milk quality (13). They reported that a high level of nutrition will reduce the level of milkfat but increase milk protein and casein. Conversely, a negative energy balance will decrease milk protein and increase milkfat. Milk protein will increase with an increased level of dietary protein. When feeding higher levels of concentrate in the diet, milkfat will be decreased and milk protein will be increased. The degree of impact from nutrition of the ewe will obviously be limited by the potential milk production capacity of the animal dictated by genetics.

## Genetics

In dairy animals, researchers have found that many of the milk proteins can exist in more than one genetic form. These genetic variants of milk proteins have also been reported in dairy sheep (14,15,16). Table 9 lists several genetic variants that have been reported and the corresponding milk composition with each. Sheep with the genetic capacity to produce the CC form of  $\alpha_{s1}$  casein will generally have higher fat and casein concentrations in their milk than those animals producing the DD form. The same genetic capabilities also exist for  $\beta$ -lactoglobulin. With ewes producing CC form of  $\alpha_{s1}$  casein or AA form of  $\beta$ -lactoglobulin, the higher fat and protein in milk will represent potential increased cheese yield from that milk. In dairy cattle, certain breeds will produce a predominance of certain genetic phenotypes of milk proteins. With further research, this also could be completed for the dairy breeds of sheep.

**Table 9.** Effect of genetic phenotype on composition of sheep milk.

<i>Protein</i>	<i>Phenotype</i>	<i>Fat, %</i>	<i>Protein, %</i>	<i>Casein, %</i>
$\alpha_{s1}$ -Casein	CC	7.08	5.44	4.41
“	CD	7.00	5.30	4.26
“	DD	7.07	5.02	4.06
$\beta$ -Lactoglobulin	AA	7.13	(5.17)	4.17
“	AB	6.30	(4.98)	4.09
“	BB	6.66	(5.01)	4.05

Ref.: Pirisi, et al., 1999.

## Trends in Wisconsin Sheep Milk

When we first started processing sheep milk in 1996, most of the milk was coming from domestic breeds, e.g., Dorsets, that were typically bred for the market lamb market. Fat and milk protein levels were fairly high and cheese yields were in the 18-20% range. As the dairy genetics were introduced into the flocks in the late 1990s, milk production increased but fat and protein levels in the milk were decreasing (Table 10). This obviously impacted cheese yields and cheesemakers were becoming concerned about the milk costs for making specialty sheep cheeses. It was difficult to compete against subsidized imported sheep cheeses, e.g., Pecorino Romano, that was coming into the U.S. at prices lower than the U.S. milk costs for sheep cheeses. This promoted some research into the possible use of blends of sheep and cow milk in some specialty cheeses. The cheesemakers were able to develop some of the typical sheep cheese flavors in these blends. In some cases, we tried to use the unique flavor of sheep milk to produce reduced fat cheeses with improved flavors (17). Table 11 shows one of these blends used for a specialty reduced fat cheese.

**Table 10.** Trend in sheep milk composition in Wisconsin, 1996-2000.

<i>Year</i>	<i>Sheep</i>	<i>Fat, %</i>	<i>Protein, %</i>
1996	Dorset	5.9-8.7	---
1996	EF-cross	5.4-6.5	---
1997	Dorset-cross	5.54	5.42
1997	EF-cross	5.04	4.96
2000	1/2 EF-cross	5.49	4.65
2000	1/2 Lacaune-cross	5.89	4.91

**Table 11.** Composition of mixed milk for reduced-fat Muenster cheese production.

<i>Component</i>	<i>Cow only</i>	<i>80:20 Cow/Sheep</i>
Solids, %	9.78	11.48
Fat, %	1.39	1.73
Protein, %	3.08	3.92
Casein, %	2.38	3.02
C/F ratio	1.71	1.74

Ref.: Ponce de Leon-Gonzalez, et al., 2002.

### **Milk Composition and the Relationship to Cheese Yield**

As we showed in Figure 1, fat and casein are the two primary milk components that are recovered in the cheesemaking process and are directly related to cheese yield. Since casein is the key component in making up the curd matrix that entraps the fat globules, we look at casein relationships with other milk constituents to forecast the potential cheese quality and cheese yield. The C/F ratio is critical in controlling the final fat in the dry matter (FDM) of the finished cheese. Minimum FDM specifications are established for many of the cheeses with standards of identity. The C/TP ratio will give us some potential information on the amount of intact casein that is present in the milk to give us a good gel structure during curd formation. Some of the reported C/F and C/TP ratios for various breeds of dairy sheep are shown in Table 12. Typical C/F ratios needed to produce high quality commodity cheeses are shown in Table 13. In most cases, sheep milk would need to be standardized by removing some cream in order to increase the C/F ratio to produce most of these varieties of cheese. For reduced fat cheeses, significant amounts of fat would need to be removed or additional amounts of solids not fat (SNF), e.g., nonfat dry milk would need to be added to match the targeted C/F ratio needed to produce a quality cheese in an efficient manner. If C/F ratios are significantly lower than the target level, high losses of fat in the whey will be experienced and the cheese yields will be decreased.

**Table 12.** Casein relationships for breeds of dairy sheep.

<i>Breed</i>	<i>C/TP ratio</i>	<i>C/F ratio</i>	<i>Reference:</i>
Lacaune	.783	.596	2
Boutsico	.760	.598	2
Karagouniko	.732	.679	2
Friesland	.792	.631	2
E. Fresian cross	.763	.700	10
Italian species	.797	.632	9
Cyprus species	.774	.685	18

**Table 13.** Ideal casein/fat (C/F) ratios in cow milk for commodity cheeses.

<i>Cheese</i>	<i>C/F ratio</i>
Cheddar	0.70
Mozzarella	0.85
Swiss	0.85
Parmesan	0.80
Havarti	0.60
Reduced fat Muenster	1.73

### Sheep Cheese Yields

Cheese yields for sheep milk have been reported in literature by various researchers. Cheese yields have been reported in the following manner:

- 1) Gross cheese yield after 1 day, lb/100 lb. (3,4)
- 2) Adjusted cheese yield to  $x\%$  moisture. (16)
- 3) Quantity of milk (Kg) of milk necessary to make 1 Kg of full-fat cheese. (14,18)
- 4)  $Y = a + b_f x_f + b_p x_p$  (18)  
 $= -0.20 + 0.011 \text{ fat} + 0.025 \text{ protein}$

Some typical cheese yields of several varieties of sheep milk cheeses are shown in Table 14. These cheese yields will vary based on the previous factors we discussed affecting milk composition, especially fat and casein concentrations. Cheese yields also may be affected by various processing variables that we will list later.

**Table 14.** Reports in literature on cheese yields from sheep milk.

<i>Cheese</i>	<i>Yield, %</i>	<i>Reference:</i>
Manchego	16.7	3
Feta	18.1	3
Romano	20.2	3
Blue	21.9	3
Halloumi	18.4	18
Manchego type	16.1	10

### Predicting Cheese Yield

The cheese yields listed in Table 14 were measured after the cheese manufacturing process was completed. There was no opportunity for the cheesemaker to predict the potential cheese yield and make adjustments to possibly improve those yields with milk standardization or changing of the make procedure to improve the recovery of milk solids in the final cheese. When using cow milk, cheesemakers have had cheese yield formulas for over 90 years that are used to predict the potential cheese yield, based on milk composition. In 1910, Van Slyke and Publow (19, 20) proposed the first cheese yield equation to determine potential yield of Cheddar cheese from cow milk. The well established Van Slyke Cheddar Cheese Yield Formula is as follows:

$$\text{Yield} = \frac{(0.93F + C - 0.1)1.09}{100 - W}$$

where: F = fat concentration in the milk, %  
 C = casein concentration in the milk, %  
 W = moisture, expressed as Kg water per Kg of cheese

Van Slyke and Price (20) also reported another cheese yield formula that was slightly modified:

$$\text{Yield} = (F + C)N$$

With this equation, they provided a table of numbers for N, based on the moisture content of the cheese. This equation did not include a provision to adjust the cheese yield for fat and casein losses in the whey as the previous formula. Hence, the Basic Van Slyke Cheddar Cheese Formula is the one that has been used extensively in the industry and is used as the basis for the multicomponent pricing system used for pricing of raw milk from the producers. This is also the formula used to predict cheese yield potential for sire services and potential production capacity of breeding stock.

The Van Slyke Cheese Yield Formula was developed for Cheddar cheese. It was based on the premise that about 7% of the fat and about 4% of the casein would be lost in the whey. Other cheeses may have different rates of recovery of milk components in the make procedure and the yield formula may need to be adjusted for that make procedure. Such is the case for Mozzarella cheese where Dr. Barbano (21) at Cornell University revised the Van Slyke formula to effectively predict cheese yield for this commodity cheese. His revised formula is as follows:

$$\text{Yield} = \frac{[(.85 \times \% \text{ fat}) + (\% \text{ casein} - 0.1)1.13]}{1 - (\text{cheese moisture}/100)}$$

These previous formulas were based on cow milk that typically had about 2.5% casein in the milk. As the solids level in milk increases, the estimated loss of 0.1% casein in the whey may not be as accurate as desired. To adjust the Van Slyke formula for higher solids milk, e.g., Jersey milk, and for other potential cheeses, Kerrigan and Norback (22) revised the Van Slyke formula to allow for use of specific fat and casein retention factors for each cheese plant or each variety of cheese produced within a plant. Their formula is as follows:

$$\text{Yield} = \frac{[(RF \times F) + (RC \times C)]RS}{1.0 - W}$$

where: RF = fat retention factor  
 F = % fat in the milk  
 RC = casein retention factor  
 C = % casein in the milk  
 RS = solids retention factor  
 W = moisture in the final cheese, (%/100)

With this formula, a cheesemaker can incorporate retention factors that are typical for that specific plant and the variety of cheese being produced. In the original Van Slyke equation for Cheddar cheese, the assumption was that a cheesemaker would experience 93% recovery of fat and 96% of the casein in the cheese. In the final cheese, there was about 9% additional solids in the form of whey proteins, lactose and ash that was present in the whey that was the moisture portion of the cheese. As moisture in the cheese increases, the RS will also increase and that is the basis of the RS of 1.13 for Mozzarella cheese as reported by Dr. Barbano (21). Retention factors for Cheddar, Mozzarella, and Swiss cheese are shown in Table 15 (23).

**Table 15.** Fat and casein retention factors for commodity cheeses.

<i>Cheese</i>	<i>RF factor</i>	<i>RC factor</i>	<i>RS factor</i>
Cheddar	.93	.96	1.09
Mozzarella	.85	.96	1.13
Swiss	.77	.94	1.10

Ref.: Kerrigan & Johnson, 1985.

### **Predicting Sheep Cheese Yield**

With the wide variation in sheep milk composition that we have experienced over the past 6 years, our cheesemakers have requested a cheese yield formula to use to predict potential cheese yields from sheep milk. We have not been able to find a widely accepted cheese yield formula covering traditional sheep milk cheeses. Since the cheesemakers are very familiar with the use of the modified Van Slyke formula for their cow milk cheeses, we were hoping that we could determine retention factors that could be used in the Van Slyke formula to allow us to predict potential sheep milk cheese yields. Some fat and protein retention values have been reported for non-traditional sheep cheeses (Table 16). There are wide variations in fat and protein retention in the cheeses reported.

**Table 16.** Fat and protein recoveries from sheep milk.

<i>Fat recovery, %</i>	<i>Protein recovery, %</i>	<i>Reference:</i>
78.0-81.4	75.4-79.5	9
65	65	24
86.9	78.6	18

To assist the Dairy Sheep Coop in establishing some type of mechanism for pricing higher solids milk for producers and to provide some mechanism for cheesemakers to determine potential cheese yields from sheep milk, we have set up a study to develop cheese yield equations for some traditional sheep milk cheeses. The objectives of the study are:

1. To determine cheese yield for a hard and a soft sheep milk cheese.
2. Determine the impact of lactation or season on cheese yield.
3. Establish cheese yield formulas for sheep milk.

This first year we are evaluating the production of Manchego-type cheese with early, mid, and late lactation milk. Next year, we will follow up with a traditional soft-type cheese with the same lactation periods. Once we have been able to establish fat and protein recovery values for these varieties of cheese, we will propose cheese yield equations that we will evaluate with our cheesemakers for potential use in the future.

Cheese yield formulas are very useful in pricing milk and providing an estimate of cheese yield under defined conditions. Calculated yields are theoretical cheese yields only. The actual cheese yields obtained may be impacted also by processing conditions in the plant. Some of the factors that the cheesemaker has control over are as follows:

1. Storage of milk
2. Milk standardization
3. Heat treatment of milk
4. Homogenization
5. Type of coagulant
6. Curd firmness at cut
7. Salt addition
8. Moisture loss during ripening.

With good process control, recordkeeping and consistent cheesemaking operations, the cheesemaker should be able to have uniform composition and cheese yields throughout the season. This should then result in an efficient and profitable business for the dairy sheep industry.

In conclusion, with milk costs representing about 85% of the cost of making cheese, it is critical that the cheesemaker is able to recover the maximum amount of fat and casein in the form of cheese to provide for an efficient operation. On the other hand, producers that are providing additional solids in their milk supply should be properly compensated for the added value that represents in the form of potential increased cheese yields. With the development of an acceptable cheese yield formula for sheep milk, we are hoping that we can provide a win-win situation for the whole dairy sheep industry.

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# ECONOMICS OF WINTER MILKING FOR MEDIUM TO LARGE DAIRY SHEEP OPERATIONS

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## Words of caution

Although all efforts have been made to be as accurate as possible, numbers given in this article have to be taken with caution. They reflect one type of operation only while there are about as many types of operation as there are producers. Receipts and expenses can vary greatly according to conditions, resources, management skills and philosophy of the operator.

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## Introduction

As in any enterprise, milking sheep and selling the milk (or processed products) is all about making a profit. Of course, the financial return will be variable according to the producer's reasons for starting a dairy sheep business (practical and/or philosophical), and reasons which are going to influence the type of operation. Nevertheless, no matter the type of operation, it has to be a profitable one while respecting the agro-ecosystem principles of sustainability. There are practically as many types of operation as there are producers, but in North America most sheep dairy enterprises are small-scale family businesses (50-150 ewes) either looking for a supplemental income, or trying to provide a full time occupation to at least one member of the household. These types of operations are generally oriented toward low labor and financial inputs, lambing late in the spring to reduce the needs of buildings and to take advantage of the growth of grass to cover the high nutritional demands of the ewes in full production. With this system, milk is generally produced at a lower cost but the lactation length is shorter because of the declining length of days and because of the high summer temperatures. In larger operations (more than 200 ewes) the initial investment for sheep dairying could be substantial because of the need for better milking equipment, larger freezer, etc. Such operations could look at the feasibility of milking all year around dividing the flock for spring, autumn and winter lambing. However, the system we are mostly interested in this article has older ewes lamb in early winter and young ewes one or two months later. Although demanding more labor and feed inputs, winter lambing and milking offers many advantages.

## Implications of winter lambing and milking

*Milk production.* In this system, the total milk production should be maximized to cover the higher cost of production. Some natural factors such as cold temperatures optimize feed intake, which favors higher milk production. The lengthening of daylight also favors milk production by sustaining lactation for a longer period. Higher milk production can be achieved by removing lambs from their dams soon after birth, raising all lambs on milk replacer and milking the ewes twice per day 3-4 days post parturition. About 30% of the total milk yield is produced during the

first month of lactation. This system is routinely used at the Spooner Research Station. However, ewe lambs (1st lactation ewes) are generally allowed to raise their lambs during the first 30 days, unless the ewe appears to be a heavy milker. The average milk production of all ewes during the 2002 season at the Spooner Research Station is shown in Table 1. It shows an average production of 240 liters (547 pounds) for mature ewes and of 120 liters (274 pounds) for young ewes in 1st lactation). This production is for crossbred East Friesian or crossbred Lacaune ewes. The complete milking (twice a day- no more lambs) or partial milking (once a day but ewes are raising their lambs) during the first month of lactation has to be seriously considered when working with high producing ewes. The amount of milk produced by those ewes during the first 30 days is generally well above the needs of 2 or even 3 lambs. The surplus milk should be collected to avoid high rate of mastitis.

The receipts shown in the example are substantiated by the monthly receipts from milk and animals sold (lambs, ewes, rams) during the year 2002 by the Spooner Research Station (Table 2).

*Labor.* There is no doubt that winter lambing requires more labor because, with climate such as in Wisconsin, lambing occurs in a shed. Lambs are generally isolated in lambing jugs, stored feed has to be distributed, pens have to be cleaned etc. Moreover, the rearing of lambs on milk replacer will add an extra burden unless the producer is well set up for this endeavor. We consider that 1-1/2 person, beside occasional family help, are needed for the care, lambing, and milking of 300 ewes.

Labor is well utilized at a period when outside work is near impossible. Peaks of lactation for most ewes (therefore longer milking time) occur before field work begins. In spring when outside work becomes possible and necessary, milking is already in a routine phase. When summer comes, milking can be phased down to once a day or better yet to 3 milkings in 48 hours (milking time could be 6 am, 10 pm, 2 pm etc...) leaving more time for family summer activities.

*Feed.* The highest nutritional needs (end of gestation and early lactation) are met with expensive stored feed. The needs are generally covered with high quality hay and corn. Dairy quality hay can cost as high as \$135 a ton. The use of haylage (\$30 a ton directly from the field) should be strongly considered if it is readily available from a neighbor. During the months of November, December and January ewes are given roughly 1.8 kg (4 pounds) of average quality hay (or 4 kg – 9 lbs haylage) and 2.8 kg (6 pounds) of high quality hay during the first 3 months of lactation (or 5 kg – 11 lbs haylage). A dairy quality grain supplement (16% CP) is provided at a rate of .9 kg/day (2 pounds) during the first 3 months and at a rate of .45 kg (1 pound) for the next 3 months). As soon as the growing season allows, all ewes are grazed on 30 acres of kura clover-orchard grass pastures in a rotational grazing system. The quantity of feed needed for a dairy ewe during the year according to this type of management system is shown in Table 3.

Lambs consume 47 kg (103 pounds) of a 21%CP creep feed between birth and sale at a live weight of 27 kg (60 pounds). Lambs that are fed to slaughter weight consume another 122 kg (268 pounds) of a 12% CP finishing ration. Those lambs are sold at a minimum live weight of 55 kg (120 pounds). Winter lambs are generally sold at the highest price (May-June). Moreover it is sometimes possible to take advantage of the “Greek” lamb market in March or April.

Lambs raised on milk replacer consume an average of 8 kg (18 pounds) of milk powder between birth and weaning at 28 days of age. High quality lamb milk replacer can be purchased for US \$2/kg (92ct/lb) when ordered in large quantity.

*Equipment and buildings.* The equipment requirement for the milking of 300 ewes is independent of the type of management and season of milking. The system has to be efficient for a rapid milking twice a day, and the freezing capacity (if milk is sold frozen) should be sufficient for the rapid freezing and storage of 350-450 liters (800-1000 pounds) of milk daily during the peak of lactation (see Table 1 in April-May). An additional advantage of winter or early spring milking is that the freezer does not work quite as hard as in June, July or August.

Buildings are necessary for a successful winter lambing especially in cold areas. Their role is to provide protection against the natural elements and therefore do not need to be very sophisticated. They should consist of a main barn where lambing occurs and where ewes spend a minimum amount of time (a few days) and several three-sided shelters with loafing areas where recently freshen ewes and young lambs are transferred to shortly after lambing. "Hoop" or "Green house" type barns with natural ventilation are a good investment for the rearing of lambs on milk replacer. They are quickly set up for a fraction of the cost of a more permanent building. The necessary buildings will significantly increase the fixed cost of the operation. However on well established farms, buildings are generally present and can be used for sheep with little investment cost.

The concentration of sheep in a barn has always been perceived as a leading cause of pneumonia. Therefore barns should be well ventilated. East Friesian lambs or high percentage East Friesian crossbred lambs being very susceptible to pneumonia, their rearing in barns should be of some concerns. However, in our experience we found that pneumonia in lambs is much more prevalent in spring lambing when there is a wide variation of temperature between days and nights.

*Bedding.* Winter lambing and the use of buildings leads to a high consumption of bedding especially in a dairy sheep operation. The conventional straw bedding is becoming very expensive. In order to keep the 300 ewes of the operation (and their lambs) as clean as possible for milking, a total of 35 tons of straw might be necessary. Good quality straw is difficult to find in the Midwest for less than \$60/ton. Alternatives such as slotted floor could be a solution to reduce the cost of bedding.

## **Budget analysis**

The following budget analysis is for a winter lambing operation with 300 ewes (250 mature ewes and 50 young ewes). The example does not include the incentives provided by the government through the farm bill (ewe lamb payment, feeder or slaughter lamb payment, wool payment). The milk is sold at a fixed price without consideration of its composition (fat and protein). This practice is widely accepted at the present time for lack of a good formula that could adequately estimate cheese yield according to the composition of the milk. It is understood that lower milk production could be compensated by higher fat and protein percentages if a sliding scale payment system was in use. All receipts and all variable expenses of the example are

realistic and directly derived from the Spooner Research Station (Tables 1 and 2). Fixed expenses, however, are more controversial. Thus the example is given with a high and a low debt service.

The Return to Labor and Management (the take home pay of the producer) is as low as \$15,000 with a high debt service and as high as \$33,000 if the farm has a low debt service. High fixed expenses appear to be the leading cause of the high cost of production. Variable expenses can be lowered only as long as it does not affect the well being of the animals **and** of the operator. In our example, the ewe feed cost represents 35% of the variable expenses and it is certainly possible to reduce this amount without affecting the total milk production. Research has shown that high producing ewes, have a better feed efficiency than lower producing ewes. Therefore, with higher producing ewes, the ewe feed cost/receipt from milk ratio would be greatly improved. Also, a less expensive feedstuff than dairy quality alfalfa hay such as haylage should be envisaged.

Total income, also, has a large influence on the Return to Labor and Management, and in the case of a dairy operation, the sale of milk can represent 65% of the total income. Table 4 shows that with the same number of ewes and the same expenses, a flock milk yield of at least 180 liters (high debt) and 120 liters (low debt) is needed to reach the breakeven point. 180 liter/ewe is a respectable average flock yield, which cannot be obtained with poor quality feedstuffs and mismanagement. Moreover, with a lower yield, it would become difficult to sell high price breeding stock. In a winter lambing operation, cost of production can be reduced only by so much before dramatically reducing the total income and thus the Return to Labor and Management. Spring lambing systems, on the other hand, offer more possibilities for the reduction of cost of production and have been shown to allow for a slightly better Return to Labor and Management, at least in a lamb/wool only operation.

The adoption of a lambing system, however, is more often dictated by the conditions, the resources, the availability of goods in or around the farm rather than by real choice. It will be up to the ingenuity, the knowledge, and the skills of the producer to make it work.

<b><u>RECEIPTS</u></b>			Unit price	Total US\$
Feeder lambs	330 lambs	27 kg	1.65	14701
Slaughter lambs	110 lambs	55 kg	1.54	9317
Breeding ewe lambs	40 lambs		200	8000
Breeding ram lambs	5 lambs		500	2500
Sale of older ewes	50 ewes		100	5000
Sale of older rams	2 rams		500	1000
Wool	1200 kg		.44	528
Milk from older ewes	233 ewes	240 l	1.24	69341
Milk from ewe lambs	50 ewes	120 l	1.24	7440
<b>Total receipts</b>				<b>117827</b>

## VARIABLE EXPENSES

### **EWE FEED**

Pasture 6 months \$1.50/head/mo	285 ewes		9.00	2565
3 month hay 1.8kg/head/day	300 ewes	162 kg	.10	4860
3 month hay 2.8kg/head/day	285 ewes	252 kg	.15	10773
1 month corn .45 kg/day	300 ewes	13.5 kg	.08	324
3 months dairy ration .90kg/day	285 ewes	81 kg	.15	3463
3 months dairy ration .45kg/day	200 ewes	40.5 kg	.15	1215
Mineral	300 ewes	6 kg	.66	1188

### **Total ewe feed**

**24388**

### **LAMB FEED**

Creep feed 21%CP	580 lambs	47 kg	.20	5452
Finish ration 13%CP	115 lambs	122 kg	.14	1964
Hay replacement ewes	60 ewes	150 kg	.15	1350
Corn for replacement ewes	60	100 kg	.08	480
Milk replacer	420 lambs	8 kg	2	6720

### **Total lamb feed**

**15966**

### **LIVESTOCK EXPENSES**

Shearing	300 ewes		2	600
Marketing-trucking of lambs				1300
Vet-Med				1000
Supplies – sheep				1500
- milking				2000
Bedding straw	35 tons		60	1750
Utilities - electricity freezer				2500
- other				1000
Machine operation cost				1500
Ram cost				2000
Hired labor	900 hours		9	8100
Maintenance and repairs				1000
Operating loan interest				2000
Pickup truck expenses				1500
Misc.				1000

### **Total livestock expenses**

**28750**

### **Total variable expenses**

**69104**

<b><u>FIXED EXPENSES</u></b>	Investment	Terms (years)	Interest rate	High debt service	Low debt service
Farm payment	150000	30	6%	10800	0
Livestock	20000	20	6%	1720	0
Sheep equipment	15000	15	8%	1716	0
Buildings	30000	15	8%	3432	0
Milking equipment (include freezer)	50000	15	8%	5712	5712
Vehicle	10000	4	5%	2760	2760
Machinery	15000	5	6%	3480	3480
Feed storage	5000	10	8%	732	732
Property taxes				2000	2000
Insurance				1000	1000
<b>Total fixed expenses</b>				<b>33352</b>	<b>15684</b>

### **RETURNS**

Total income		117827	117827
Less variable expenses		-69104	-69104
<b>Return to labor and capital</b>		<b>48723</b>	<b>48723</b>
Less fixed expenses		-33352	-15684
<b>Return to labor and Management</b>		<b>15371</b>	<b>33039</b>
		\$51/ewe	\$110/ewe

### **Cost of production of milk**

Since the cost of production of milk is the difference between the receipt from the sale of milk and the expenses solely occurred for the production of this milk, it should roughly be similar in many types of operations. Expenses imputable to milk production are found in all expense categories.

*Ewe feed.* Not all ewe feed is imputable to milk production. If ewes were not milked, they would still need to be fed accordingly for the production of lambs, unless lambs become a secondary product (most lambs sold at one day of age, for example) in which case all feed (and expenses) would be attributed to milk production. Feed cost at the end of gestation and early lactation are basically the same between a meat only operation and a dairy operation. The difference comes in a longer period of high quality feedstuff, mostly in terms of concentrates. In a meat only operation ewes would be fed corn for 45 days post parturition instead of a higher priced dairy ration for 6 months. Therefore, in the example the extra ewe feed cost imputable to dairying amounts to US\$ 4030.

*Lamb feed.* In a dairy operation lambs are weaned at 30 days or earlier which translates into a higher consumption of expensive creep feed (+ 20 kg/lamb between day 30 and 60) and of finish ration (+32kg/lamb) for a total of US\$ 2835. Lambs weaned at an early age need to receive a high protein ration and cannot be put on forage. The extra cost cannot easily be decreased.

**Supplies.** Supplies for milking such as detergent, acid, brushes, liners, milk tubes, milk filters etc... and lab cost for milk analysis is estimated at US\$ 2,000.

**Utilities.** The single most expensive item is the operating cost of the commercial freezer estimated at US\$ 2,500 for the milking season.

**Labor.** With an efficient system, the milking of 280 ewes should not last more than 4-5 hours a day as an average over the all season of 180 days. Considering that the producer's salary should be at least \$13/hour, the cost of labor for milking is US\$ 11,700. Moreover, about 3/4 of the hired labor cost is imputable to the dairy operation or US\$ 6,075. The total labor cost for the milking and extra care of 270 ewes is therefore US\$ 17,775.

**Milking system.** The cost of amortization of the milking system is imputable to milking, that is, US\$ 5712.

The total cost of production of the 61,920 liters (220 liter flock average) of milk in the system described above is US\$34,852 or **.56/liter**. The difference between the cost of production and the sale price of milk represents the deficit or the profit of the dairy operation in the overall sheep enterprise. The cost of production varies greatly according to the average milk yield of the flock as shown in Table 5.

Table 1. Number of ewes, average milk production, % fat, % protein at each testing day (every 28 days) during the 2002 season at the Spooner Ag. Research Station (all breeds or genotypes confounded). Production given in liters. 1 liter = 1036 g = 2.28 pounds

Test Date	2, 3, 4 year old ewes				1st lactation, 1 year old ewes			
	# of ewes	Milk (liters)	% fat <sup>1</sup>	%prot <sup>1</sup>	# of ewes	Milk (liters)	% fat <sup>1</sup>	%prot <sup>1</sup>
2/5/02	30	2.77	6.75	5.87				
3/5/02	153	1.81	7.19	5.58				
4/2/02	185	1.78	6.40	5.00	33	1.66	6.80	5.30
4/30/02	181	1.41	5.80	5.06	78	1.51	5.80	4.74
5/28/02	176	1.46	5.29	4.90	134	1.56	5.29	4.60
6/25/02	172	.95	5.97	4.70	148	1.00	5.58	4.40
7/23/02	159	.80	6.54	5.00	143	.80	6.17	4.80
8/20/02	138	.60	7.72	5.90	128	.60	7.45	5.70
9/18/02	138	.50	7.50 <sup>2</sup>	5.73 <sup>2</sup>	128	.50	7.50 <sup>2</sup>	5.73 <sup>2</sup>
# of ewes at breeding		200				170 <sup>3</sup>		
# of ewes put at milking(%)		185 (93%)				148 (87%)		
Average milk production		240 liters <sup>4</sup>				120 liters <sup>4</sup>		

<sup>1</sup> Average of individual samples

<sup>2</sup> Bulk tank composition

<sup>3</sup> The Spooner Research Station retains many more ewe lambs than necessary because of its genetic research program.

<sup>4</sup> Include all ewes having entered the milking parlor for at least 4 days

Table 2. Amount of milk and number of animals sold per month, and monthly receipts (milk and animals) during 2002 at the Spooner Research Station (UW-Madison).

Months	Milk (liters)	Animals (#)	Receipts milk US\$	Receipts animals US\$	<b>Total Receipts US\$</b>
January	492	0	611	0	<b>611</b>
February	3704	0	4602	0	<b>4602</b>
March	9518	0	11827	0	<b>11827</b>
April	9640	195	11979	9417	<b>21396</b>
May	11820	136	14687	7185	<b>21872</b>
June	11355	0	14109	0	<b>14109</b>
July	8411	15	10451	951	<b>11402</b>
August	5113	25	6353	2406	<b>8759</b>
September	2394	95	2974	9081	<b>12055</b>
October	0	105	0	12950	<b>12950</b>
November	0	0	0	0	<b>0</b>
December	0	0	0	0	<b>0</b>
<b>Total</b>	<b>62447</b>	<b>571</b>	<b>77593</b>	<b>41990</b>	<b>119583</b>

Table 3. Quantity of feed needed by a dairy ewe during the year.

	Complete confinement all year around	Semi confinement winter lambing	Semi confinement spring lambing
Average quality hay	486 kg	162 kg	324
Good quality hay	252 kg	252 kg	0
Corn (kg)	148	120	80
Soybean meal (kg)	20	18	12
Pasture	-	4 month high quality 2 months low quality	6 month high quality

Table 4. Expected returns to labor and management according to the price of milk and milk yield considering all other receipts and expenses similar to the example with a high debt service (**bold**) and low debt service (*Italic*).

Price of milk in US\$/liter	Average milk yield of the flock in liters					
	140	160	180	200	220	240
1.14	<b>(-16243)</b> <i>1425</i>	<b>(-9791)</b> <i>7877</i>	<b>(-3338)</b> <i>14330</i>	<b>3114</b> <i>20783</i>	<b>9566</b> <i>27236</i>	<b>16019</b> <i>33689</i>
1.24	<b>(-12281)</b> <i>5387</i>	<b>(-5263)</b> <i>12405</i>	<b>1756</b> <i>19423</i>	<b>8774</b> <i>26441</i>	<b>15792</b> <i>33459</i>	<b>22810</b> <i>40477</i>
1.37	<b>(-4755)</b> <i>10537</i>	<b>624</b> <i>18292</i>	<b>8378</b> <i>26028</i>	<b>16132</b> <i>33783</i>	<b>23886</b> <i>41738</i>	<b>31640</b> <i>49293</i>

Table 5. Cost of production of a liter of milk in a winter lambing operation according to the average milk yield of the flock.

Average milk yield of the flock in liters						
100	120	140	160	180	200	220
\$1.23/l	\$1.03/l	\$0.88/l	\$0.77/l	\$0.68/l	\$0.62/l	\$0.56/l

# **START-UP AND OPERATING COSTS OF SMALL FARMSTEAD CHEESE OPERATIONS FOR DAIRY SHEEP<sup>1</sup>**

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## **Introduction**

Farmers with sheep dairies may want to look at the option of making cheese on their farm instead of selling whole milk to a cheese processor. This type of enterprise will require added labor for marketing and cheesemaking and extra costs to build the cheese facility.

In this paper, in Part I, examples of actual costs of setting up 3 cheesemaking operations along with some dimensions of rooms and lists of equipment are given. These actual set-up costs focusing on the cheese facilities are provided from 2 sheep and 1 goat dairy in Vermont. Each started construction around the years 1997-1998.

In Part II, some sheep dairy farms' financial summaries will be provided with a basic description of the operation. This will allow individuals interested in seeing costs/income associated with different sizes and types of operations to be able to compare different scenarios.

Operating budgets from 4 sheep dairies in Vermont and New Hampshire in their initial full year of operation is presented. Each farm had differing capital investments to carry for the whole farm and their depreciation and loan repayment costs are not presented. The financial data from these 4 farms was taken from one of the calendar years of 1998-2000, depending on the farm. All the farms made a hard, pressed, aged cheese that they sold 'green' (before aging) to another business that aged the cheese and marketed it under their own name. In effect, the farms were getting a wholesale price for what would be turned into a gourmet cheese.

The farmers sold their cheese to the affineur/marketer for up to \$5.70/lb final product (some shrinkage occurs during the 4-6 months of aging). The affineur/marketer sold the cheese, depending on the final grade of quality for between \$9.00 to \$11.50/lb. wholesale and between \$12.00 to \$18.50/lb retail. The aging process required the investment of constructing an underground cave and paying for a full-time affineur to tend to the cheeses. However, one of the biggest costs going into the final product is the bookkeeping/promotional material/shipping that together make up the cost of marketing.

<sup>1</sup>Funded by the Vermont Sustainable Jobs Fund, Montpelier, VT 05602 and UVM Center for Sustainable Agriculture, Small Ruminant Dairy Project

## Part I: Costs of setting up a sheep dairy with cheese-making facilities

From the following examples, we find that it can cost as little as **\$10,000** to build cheese making facilities and equip it if you are willing to do the labor yourself, buy used equipment and use multi-purpose vats (one that pasteurizes as well as cultures the curd). This is gleaned from **Example 1** where some of the actual building costs are hidden in the initial barn set up (\$30,000) where the whole dairy is housed (winter area for goats, milking parlor, milk room and cheese room). Even though this data is from an organic goat dairy, the set-up costs here should be identical for sheep. Another entry from this farm is the cost of setting up a one room house for interns which was “the best investment we made” according to the farmers.

In **Example 2**, the farmers had an existing barn, recently rebuilt after a fire, to start from. While they were able to start milking and making cheese for about **\$15,000**, they added a better combination cooler/pasteurizer/cheese vat for an additional **\$12,000** two years later. Wanting to offer cave-aged cheese increased their investment another **\$27,000**. Except for some specialty stone work on the cave, the cheese room and cave facilities were built by the farmers’ labor. It is worthy to note that this farm has won more than a handful of American Cheese Society cheese contest awards.

If you think you will be building everything from ‘scratch’ that will be solely for a cheese facility and where tourists will be welcomed, the sheep dairy in **Example 3** gave a price tag of between **\$40-\$50,000**. This farm built their facilities with an eye for having the public coming to the farm for tours and for buying cheese. This probably increased the cost of the building but, again, they used mostly their own labor for construction. [Example 3 is the same farm as Sheep Dairy 4 in Part II.]

### Example 1                      Goat Dairy      Milking 20

Barn \$30,000 30’X60’ including plumbing and furnace and own labor.

4 stall parlor with stanchions (9’ X 9’) cost \$2,000 for system and stand

Milk room (9’ X 9’)

septic system

Wood heated boiler for pasteurizer, water and barn \$7,000

Cheese room made with used equipment and own labor (9’ X 20’)

Kettle cheese vat \$3,000 plus \$1,000 to equip plus 400 cheese molds

Used refrigerators \$200

Sink \$100

Draining table \$180

Dairy panel \$500

Aging cooler \$500; Cooler room (5’ X 9’)

Aging cellar \$? Not done....(10’ X 22’)

Solar Barn, 20' X 80', expansion for goats \$8,000

Intern house \$4,000 no plumbing; one room 16'X20'

Lumber \$1050-1350

Wiring \$215

Paint \$100

Roof \$535

Housewrap \$90

Insulation \$300

Sheetrock \$225

Concrete tubes \$145

Windows and doors \$115-215

Monitor heater \$700

Ditch machine rental \$40

Misc \$65

**Example 2                  Sheep Dairy                  Milking 50**

Parlor and Cheese Plant combined - \$15,000

some foundation existing; own labor; dairy board and painted plywood paneling

[first and second year]

Parlor - \$3,000 12'X30'

12 headgates and bucket milking machine and vacuum

Cheese vat - \$750

5 gallon custom made including knife

Milk Room 10'X20'

Air Lock room 10'X6'

Cheese Room 16'X20' has 5'X7' cooler

Compressor, used, \$200

Can cooler - free; needed recharging of refrigerant

Two milk cans

[borrowed a 40 gallon vat for during second year]

[third year]

Combination bulk tank/vat/pasteurizer/Mueller 100 gallon- \$12,000

40 gallon kettle vat from Jacque Brousseau \$600 (own labor to install)

replaced defective valve for \$650

Chart recorder less than \$1,000

Two reconditioned thermometers \$400

[fourth year]

Vat 100 gallon - \$3500

Yogurt capper

Cave -\$27,000 own labor built 2 walls on back wall of ledge. Hired stone work and façade.  
Concrete culverts. Did own painting, plumbing and electrical work.

Well-\$1,000 including \$200 for the concrete tile

Two compressors to keep temperature cool enough in summer - \$6,000 includes installation

Cave - \$20,000 with 2 rooms each 10'X20' separated from back ledge by 6'X20' space;  
front weighing and wrapping room 10'X16'

### **Example 3 Sheep Dairy Milking 69**

Parlor with 12 headgates \$10,000

Barn, hoop-style with steel girders, 40' X 100', owner labor only, \$20,000

Cheese Building \$40-50,000 paid labor except inside tiling

Make room 30' X 15'

Aging cooler 12 X 15'

Front office/viewing room 8' X 12'

Can cooler room 12' X 15'

Equipment \$10,000

2 vats, refrigerator, tables, racks, molds, etc.

Septic \$5,000, toilet is required by VT state for cheese facility  
(whey fed to pigs)

### **Part II: Operation Budgets of 4 farmstead cheese sheep dairies**

- Operators: Farm couple, one full-time on farm, one part-time with part-time off-farm job
- Hired labor: Intern for 10-12 weeks
- Flock size: 110 ewes
- Production per ewe: 225 lbs. milk/lactation; 45 lbs. cheese/ewe
- Farm size: 60 acres leased
- Year in business: Second year
- Feed: grazing in summer; own hay and purchased grain
- Product: pressed, raw cheese sold green/wholesale to affineur/seller
- Cheese yield for sale: 4950 lbs.

This young farm couple had done an internship on a sheep dairy and were hoping that they could generate a full-time income from a variety of farm enterprises. During the period when the ewes were dry, maple sugaring and marketing of wool and meat products were things that contributed to their farm occupation. Both of them shared the milking and cheesemaking work and felt that they could easily handle a flock of 110 ewes. They felt it was very important to try to market the meat and wool as value-added direct sale as much as possible to make the whole operation profitable.

They said they could receive between \$4.80 to \$5.25 per pound of green cheese, if everything went well. They received payments for their green cheese before and after aging with a grading panel determining the quality premium. In terms of return on their actual milk, they earned \$0.97/lb. of milk for their raw cheese sold one year and \$0.85/lb. of milk sold in two subsequent years. If they had sold raw milk, they would have gotten closer to \$0.60/lb. of milk. They made some feta cheese [cheese yield to milk ratio of 1:4] and the wholesale price of \$7/lb. gave them a return of \$1.75/lb. of milk produced. However, they found it hard to sell the cheese at that price. The advantage of selling a green cheese for someone else to age and sell is the absence of time and expense in aging and selling. The advantage of selling their own cheese was providing them with a better cash flow and better return on their milk.

This example is unique among the 4 examples in that they rent the entire farm facility. This would allow a quicker return to investment than the other 3 examples. Their numbers in the Farm 1 column were based on averages of financial records they kept for the years in 1998 and 1999. For any missing but relevant data, they consulted with experienced dairy sheep producers to back-up their estimates.

The Farm 1P column is a projected estimate of what they thought you could expect if you just increased your milk production per ewe from 225 lbs. to 500 lbs.

<b>SHEEP</b>	<b>Farm 1</b>	<b>Farm 1P</b>
No. head	110	110
milk /ewe	225	500
Lbs cheese shipped	4950	11000
<b>INCOME \$</b>		
Cheese sales	21780	48500
Lambs	6600	6600
Wool	385	385
Culls	440	440
Other		
<b>Total cash income \$</b>	<b>29205</b>	<b>55925</b>
<b>EXPENSES \$</b>		
Grain, feed, min.	4950	4950
Forages	4730	4730
Fert, seed, testing	440	440
Gas, fuel, oil	440	440
Insurance	1100	1100
Labor	4400	4400
Land costs	7150	7150
Repairs	1000	1000
Shearing	396	396
Supplies- cheese	450	1000
Supplies other	630	630
Vet + medicine	770	770
Utilities	1000	1000
Other	440	440
<b>Total cash expense \$</b>	<b>27896</b>	<b>28446</b>
<b>Income - expense \$</b>	<b>1309</b>	<b>27479</b>
inc-exp/ewe \$	12	250
cash exp/ewe \$	254	259

## Sheep Dairy 2: Actual vs. Projected

- Operators: Farm couple, one full-time on farm, one part-time on farm with part-time off-farm job
- Hired labor: Hire custom operator to make baleage on rented acres.
- Flock size: 43 ewes (actual); 100 ewes (projected data)
- Production per ewe: 240 lbs. milk/lactation; 22.3 lbs. cheese (actual); 400 lbs. milk and 80 lbs. cheese (projected)
- Farm size: 16 acres pasture owned; 10 acres rented
- Year in business: First partial season (milked 6/5 to 8/21/99)
- Feed: grazing in summer and 2 lb. conc./day/lactating ewe
- Product: pressed, raw cheese sold green to affineur/seller
- Cheese yield for sale: 960 lbs. of cheese (actual); 8000 lbs. (projected)

While one of this couple worked a full-time, off-farm job, the hours contributed to the business was many and his expertise crucial. Plus, he sheared all their sheep. This farm used their farm data and other average costs from farm statistics to project what a 100-ewe dairy's budget would look like. They sold their cheese wholesale at about a rate of \$4.50 per pound, with most of their yield of cheese meeting highest grade standard for sale to an affineur/seller.

In reality this couple had a goal of limiting their ewes to between 40-80 in number and to increase their production from 2-3 lbs. of milk/ewe per day to 5 lbs. [Est. lactation yield from 240 lbs./ewe in the former case to 600 lbs./ewe in the latter case.] The projected case they present here for a 100-ewe dairy is of 400 lbs./ewe per lactation.

They made very high quality cheese (none rejected) and estimated that if they could earn \$1/lb of milk from 100 sheep with a 3 lb. milk/day avg. daily yield/ewe, it would pay them \$10/hour for their time worked. Their goal was for the off-farm job to be phased out and both of them 'retire' early to the sheep dairy business.

<b>SHEEP</b>		<b>Farm 2</b>
No. head		100
milk /ewe		400
Lbs cheese shipped		8000
		<b>Farm 2</b>
<b>INCOME \$</b>		
Cheese sales		36000
Lambs		6850
Wool		280
Culls		600
<b>Total cash income</b>		<b>43730</b>
<b>EXPENSES \$</b>		
Grain, feed, min.		9250
Insurance		3614
Repairs		2204
Supplies other		1500
Taxes		600
Vet + medicine		1000
Utilities		1000
Other		500
<b>Total cash expense</b>		<b>19668</b>
<b>Income - expense \$</b>		<b>24062</b>
inc-exp/ewe \$		241
cash exp/ewe		197

### Sheep Dairy 3

- Operators: Farm couple, both full-time on farm
- Hired labor: Intern for 10 weeks
- Flock size: 38 ewes
- Production per ewe: 107 lbs. milk and 17.3 lbs. cheese
- Farm size: 30 acres owned; 15 acres leased
- Year in business: First partial season (milked 6/25-8/25/00)
- Feed: grazing in summer; purchased hay and grain
- Product: pressed, raw cheese sold green to affineur/seller
- Yield for sale: 660 lbs. of cheese; purchased 570 lbs. cow milk and made into cheese.

Run by couple new to dairy sheep farming and new to this farm. Labor assistance was a 13 year old daughter and college age daughter for a short period in summer. One intern was paid \$200 per week and given room and 5 meals a week. Housing for the intern consisted of converted stalls in a former horse barn on the second floor above the cheese facility. The farmers enjoy gourmet cooking and were experimenting with other cheese and sausage recipes that they could sell retail at farmers' markets.

Their goal was to first, have the business pay for the tax burden on the farm. Since starting their farm, their property taxes have decreased by \$5,000 per year due to Vermont's Use Value Appraisal Program. Second, they did want to make a profit but they were not expecting to live on this totally, having 'retired' early from successful careers.

Since this was their home as well as their farm business, they made sure that the improvements were dual-purpose, meaning that the infrastructure they built with capital investments could convert to another use if their farmstead cheese business was not satisfactory to them. When farmers sell specialized buildings, they rarely make a profit. Be aware that it is easy to over-capitalize.

They milked 38 crossbred ewes (30 first lactation and 8 multiparous culls) purchased from other sheep dairies. They lambed in April and weaned the lambs and milked from June 25-August 25, only 2 months. They had 66 live lambs and saved 31 female replacements. Having a low production year with first lactation ewes and keeping many replacements put their annual cash cost per ewe very higher at over \$400 compared with some other sheep dairies in this paper.

They produced 660 pounds of a pressed, cave-aged cheese but some batches were thrown out (~120lbs) and not included in this total which, if included, would have brought the yield of cheese per ewe to 20.5 lbs. This cheese was sold wholesale to an affineur/seller. They purchased 570 pounds of cow milk and made cheese for sale at the farmers' market besides this.

<b>SHEEP</b>		<b>Farm 3</b>
No. head		38
milk /ewe		est 100
Lbs cheese shipped		660
		<b>Farm 3</b>
<b>INCOME \$</b>		
Cheese sales		5480
Lambs		416
Culls		443
Other		2384
<b>Total cash income \$</b>		<b>8723</b>
<b>EXPENSES \$</b>		
Consulting		65
Grain, feed, min.		1486
Forages		2526
Fert, seed, testing		116
Insurance		997
Labor		2602
Land costs		553
Repairs		1072
Shearing		
Supplies- cheese		1866
Supplies other		1337
Vet + medicine		578
Utilities		624
Work animal expense		246
Other		1410
<b>Total cash expense</b>		<b>15478</b>
<b>Income - expense \$</b>		<b>-6755</b>
inc-exp/ewe \$		-178
cash exp/ewe \$		407

## Sheep Dairy 4

- Operators: Farm couple, sole operators; one has off-farm business part time
- Hired labor: Intern for summer
- Flock size: 60 ewes
- Production per ewe: 233 lbs. milk and 50 lbs. cheese
- Farm size: 45 acres
- Year in business: First commercial year
- Feed: grazing in summer, 4,000 bales harvested for winter; purchased concentrate
- Product: pressed, raw cheese sold green to affineur/seller
- Cheese yield for sale: 2000 lbs. wholesale; 1000 lbs. retail

Run by a couple in their 3<sup>rd</sup> year of farming. They had milked a few sheep in 1998, milked a few and started trying to make cheese in 1999 then, in 2000, they started what they felt was their first “commercial” year. The husband still kept a part-time non-farm business for income. They hired an intern for the summer who lived at the farm site in a trailer and was paid \$150 per week.

They built a hoopstyle barn for their sheep and were in the process of finishing their cheese building. This couple was planning to build a house next to the farm and cheese operation and move there. They intend to do little or no off-farm work and that the farmstead cheese operation with an on-farm cheese store where they could have retail sales in their highly touristique area of Vermont. They plan to continue to make the ‘green’ cheese and buy it back to sell at their store along with a few other of their own line of cheeses.

They milked 60 ewes and carried 5 rams and 17 unbred yearlings that year. They produced 2,000 pounds of pressed cheese sold green to an affineur/seller. They also made 1,000 pounds of another cheese and sold it at a health food cooperative and at a farmers’ market. Their milk yield was estimated back from this at 14,000 lbs. for the year or approximately 233 lbs./ewe per lactation. [3,000 lbs. of aged, hard cheese with a 1:5 cheese to milk weight yield gives 14,000 lbs. of milk. 14,000 lbs. of milk/60 ewes is 233 lbs. milk/ewe per season.]

<b>SHEEP</b>		<b>Farm 4</b>
No. head		60
milk /ewe		233
Lbs cheese shipped		3000
		<b>Farm 4</b>
<b>INCOME \$</b>		
Cheese sales		10732
Lambs		1527
Wool		250
Other		170
<b>Total cash income \$</b>		<b>12679</b>
<b>EXPENSES \$</b>		
Grain, feed, min.		4340
Fert, seed, testing		560
Gas, fuel, oil		910
Insurance		394
Labor		1800
Repairs		2202
Supplies- cheese		1820
Supplies other		5300
Taxes		884
Vet + medicine		959
Utilities		2100
Other		1098
<b>Total cash expense</b>		<b>22367</b>
<b>Income - expense \$</b>		<b>-9688</b>
inc-exp/ewe \$		-161
cash exp/ewe \$		373

### Part III: Discussion

It is important to identify your financial and personal goals with the cheese business before starting and to assess them annually. One farmer in the study noted that it would be best to know your sheep business and have already capitalized a lot of the sheep equipment before you begin investing in a cheese room. Also, if you are already losing money on a ewe and lamb business, you can not expect the dairy to make up for the loss and pay back its investment. Sheep dairying, including a farmstead cheese business, is an additional profit area to augment your already profitable operation.

In order to continue to be sustainable, the flock must cover its' own costs plus contribute to the family living expenses, plus pay back borrowed money plus replace depreciated equipment. The investment costs were not listed here and only Sheep Dairy 1 that rented the farm showed a small profit over costs including the rent. If you are building your capital infrastructure (barn and cheese facility) and flock at the same time as your cheese business, your trip to profits will take longer, as shown in these case studies.

It is hard to say how to advise new farmers on the decision of how to develop their sheep dairy operation. The late Olivia Mills, world renowned author of Practical Sheep Dairying said "Learn how to make good cheese, first. Anyone can milk a sheep but not anyone can make good cheese. You should be making profits in your first year of production." If you are learning the cheese trade at the same time of learning your sheep and improving production, the data here shows that you won't make a profit. The advice to take home is to start experimenting with cheese and get good at it before you invest heavily in it. Ideally, you would rent a cheese facility first or, try it in your kitchen and at cheese workshops.

Noteworthy is the example in Sheep Dairy 1 of the return per pound of milk when they made their own cheese for sale at retail prices. While they had to age and market the Feta, they received \$1.75 per lb. of milk vs. \$0.90, at most, by selling a cheese at wholesale. By combining a low investment (no pasteurization required) wholesale cheese with a different retail cheese, a new cheesemaker can slowly branch out, learn marketing and bring in more profit. Even if you market your own cheese, you will often accept a wholesale price at a vendor's like a health food store or a cheese shop. Nonetheless, cheese income per pound of milk is not the only factor that made a significant effect on cash flow.

Look at the cheese sales per ewe at the bottom of the SHEEP section at the top of Table 1 in the Appendix. Farms 3 and 4, which were beginner farmers, showed only \$144 and \$179 of cheese sales per ewe. Farm 1, with more experience, is nearly \$200, and the targets on Farm 1P and Farm 2 show goals of \$441 and \$360, respectively. Next, take a look at income per ewe. This shows the importance of lamb income when combined with cheese sales. Obviously, selling retail, as mentioned before, brings more cash, but, also demands more time, skills, and working with the public.

Another significant factor in profits is milk yield per ewe. In this data, there was a high variability in milk yield per ewe: from about 100 lbs. of milk per ewe to an actual 225 or 233 pounds, and hopes for 400-500 pounds. Dairy farms have to make good quality milk at good production rates to have a chance at profitability. Breeding plays an important part; the hope is for each generation to have the ability to produce more than the previous one. The only way to help guarantee this climb is to do milk component testing and yield recording along with udder evaluation on each ewe.

Look at the actual and projected profits on Sheep Dairies 1 and 2 as production is elevated to 400 or 500 pounds per ewe. The income minus operating expense line shows modest figures of between \$24,000 to \$27,5000 per year. Being a partial year enterprise, it could be combined with more enterprises or part-time off-farm work in the off-season to bring a reasonable annual income to the family.

**APPENDIX**

**TABLE 1: FARMS 1-4 COMPARED**

<b>SHEEP</b>	<b>Farm 1</b>	<b>Farm 1P</b>	<b>Farm 2</b>	<b>Farm 3</b>	<b>Farm 4</b>
No. head	110	110	100	38	60
milk /ewe	225	500	400	est 100	233
Lbs cheese shipped	4950	11000	8000	660	3000
Cheese sales/ewe	198	441	360	144	179
Total income/ewe	266	508	437	230	211
	<b>Farm 1</b>	<b>Farm 1</b>	<b>Farm 2</b>	<b>Farm 3</b>	<b>Farm 4</b>
<b>INCOME</b>					
Cheese sales	21780	48500	36000	5480	10732
Lambs	6600	6600	6850	416	1527
Wool	385	385	280		250
Culls	440	440	600	443	
Other				2384	170
<b>Total cash income</b>	<b>29205</b>	<b>55925</b>	<b>43730</b>	<b>8723</b>	<b>12679</b>
	<b>Farm 1</b>	<b>Farm 1P</b>	<b>Farm 2</b>	<b>Farm 3</b>	<b>Farm 4</b>
<b>EXPENSES</b>					
Consulting				65	0
Grain, feed, min.	4950	4950	9250	1486	4340
Forages	4730	4730		2526	
Fert, seed, testing	440	440		116	560
Gas, fuel, oil	440	440			910
Insurance	1100	1100	3614	997	394
Labor	4400	4400		2602	1800
Land costs	7150	7150		553	
Repairs	1000	1000	2204	1072	2202
Shearing	396	396			
Supplies- cheese	450	1000		1866	1820
Supplies other	630	630	1500	1337	5300
Taxes			600		884
Vet + medicine	770	770	1000	578	959
Utilities	1000	1000	1000	624	2100
Work animal expense				246	
Other	440	440	500	1410	1098
<b>Total cash expense</b>	<b>27896</b>	<b>28446</b>	<b>19668</b>	<b>15478</b>	<b>22367</b>
<b>Income - expense</b>	<b>1309</b>	<b>27479</b>	<b>24062</b>	<b>-6755</b>	<b>-9688</b>
inc-exp/ewe	12	250	241	-178	-161
cash exp/ewe	254	259	197	407	373

Cash expenses per ewe also shows more variability: ranging from \$197 to \$407/ewe. The 2 farms in the vicinity of \$400 show high start-up costs but, it looks like a cost of \$200-\$250/ewe might be attainable with a real effort at controlling costs. The dollar not spent in the barn can be used for family living.

Profit is return to the operator's time (and other unpaid family members), management, and capital investment. Profit can be used for family living expenses, savings, principal repayment, and new investments on the farm. If you plan to build a cheese business at the same time as your flock, how long can you wait before you are making enough money to live on?

Following this data, getting a loan to **start** a sheep dairy with a cheese room might be just about impossible. You can see how it would appear risky, with the farm losing money in the first years, and there being no money generated to repay a loan. Usually, with a new enterprise, a lender might only be interested in participating after several years, once you have the skills in production and marketing, and have financial records that document your progress. Then a lender may come in to help with an expansion or labor saving equipment.

It would be the least risky to first have a profitable sheep dairy selling whole milk to then, budget out and start a cheese business while it still is selling milk wholesale. This would allow for a steady cash flow and a sure, second market for the milk while the cheese business was starting to grow.

In summary, we have shared some real life costs of building a cheese rooms from the small, in-barn room to the higher cost one with a retail shop for tourists. In addition you have seen the real and projected costs and incomes from several sheep dairies that make and sell farmstead cheeses in Vermont and New Hampshire. These farmers have found that a demand exists for these specialty cheeses and they are trying to produce for this niche market. Right now, most can sell all they produce, especially if they utilize farmers' markets. We hope these figures can be used to help others work out business plans and to set realistic production and sales goals.

### **References**

Bruce Clement, UNH Cooperative Extension, handout from Vermont Grass Farmers' Association conference, February 1999.

Mike Ghia, Ewetopia Sheep Dairy, handout from Introduction to Sheep Dairying workshops, January 1999, 2000, 2001.

### **Suggested Readings**

*Developing the Farmstead Goat Cheese Business in Wisconsin* by Sara T. Bredesen, funded by the Wisconsin Department of Agriculture, Trade and Consumer Protection-Marketing Division, September 2000.

# **SOMATIC CELL COUNTS AND MAMMARY INFECTIONS ON SMALL RUMINANT DAIRIES IN VERMONT**

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## **Summary:**

A study was done comparing the value of CMT, Conductivity Testing and Electronic Somatic Cell Count compared to cultures on determining the infection status of sheep and goats. Also investigated was the type and prevalence of mastitis in the herds studied. Scott McDougall of the Animal Health Centre, Morrinsville, New Zealand was the principle investigator. 110 goats from six herds and 153 sheep from three flocks were sampled at parturition and approximately 40 days later. The sheep were sampled again at the end of lactation and the goats at the end of the year. Parturition occurred between February and April.

In the goats, 27.3% were infected at parturition and 25.5% were infected 40 days later and 23% at the end of the year. In the sheep, 15.0% were infected at parturition with 9.1% infected 40 days later and only 4% at the end of lactation. Spontaneous cure occurred in 93.8% of infected sheep halves in the first 40 days but in only 50.0% of the goat halves. Coagulase negative staphylococci were the most common isolates from both sheep and goats. At the end of lactation 100% of the infections in sheep and 80% of the infections in goats were from coagulase negative staphylococci. In both sheep and goats, milk from bacteriologically positive halves had a significantly higher somatic cell count than halves from which no bacteria were isolated.

The number of infected halves increased with age group in goats (6.8%, 19.4% and 31.6% of halves from 1+2, 3+4 and >4 year old animals;) but not sheep (4.7%, 4.3% and 0% of halves from 1+2, 3+4 and >4 year old animals, respectively).

California Mastitis Test (CMT) in both sheep and goats was shown to be helpful in determining the infection status of sheep and goats. It was not as good as an Electronic Somatic Cell Count (ESCC). Conductivity testing was not helpful in determining infection status of sheep but was helpful in goats.

ESCC per ml on sheep whose milk was bacterially “no-growth” was 382,000 at freshening, 467,000 at 40 days (also the first week milking on machine), and 258,000 at the end of lactation. ESCC per ml in goats whose milk was bacterially “no-growth” was 1,490,000 at freshening, 211,000 at 40 days and 1,111,000 at the end of the year.

The first two samplings have been written up in the following articles:

A paper entitled *Prevalence and incidence of subclinical mastitis in goats and dairy ewes in Vermont, USA* has been accepted for publication by Small Ruminant Research and is scheduled to be in the November issue.

A paper entitled “*Relationships among somatic cell count, California Mastitis Test, impedance and bacteriological status of milk in goats and sheep in early lactation*” has already been published in Small Ruminant Research.

# DNA MARKERS FOR ASEASONALITY AND MILK PRODUCTION IN SHEEP

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## Introduction

Knowledge about genetic markers linked to genes affecting quantitative traits can increase the selection response of animal breeding programs, especially for traits that are difficult to improve when using traditional selection (Meuwissen and Goddard, 1996; Meuwissen and Van Arendonk, 1992). The seasonal breeding pattern that is commonly observed in temperate sheep breeds is a major obstacle to increasing the intensity of sheep production. Sheep breeds differ in timing and duration of breeding (Notter D.R., 1992; Nugent et al., 1988; Vincent et al., 2000) but less is known about genetic variation within breeds for traits associated with seasonal breeding. Therefore, selection of sheep for aseasonal reproduction is based upon observing the animals' phenotype, which often lacks accuracy and can be done only after animals reach sexual maturity. Similarly, selection for milk production is difficult for at least two reasons. First, measuring the trait takes time and money (females need to reach maturity before expressing the trait and the lactation period lasts more than 200 days so repeated measurements are necessary to accurately assess the phenotype). Second, milk yield is a sex limited trait; therefore the males, the most important path for selection because of their higher reproductive capacity, can be evaluated only based on the phenotype of their female progeny. Furthermore, for both traits the exact molecular nature of the target genes remains essentially unknown.

Phenotypic variation usually is continuous instead of discrete and conditioned by allelic variation at several (and sometimes many) genetic loci (genes), each with a relatively small effect. Characteristics such as breeding out-of-season or milk production, where phenotypic variation is continuous and determined by the segregation at multiple loci, are referred to as quantitative traits and they have a polygenic inheritance. The individual loci controlling a quantitative trait are referred to as polygenes or quantitative trait loci (QTL). For many years, animal breeding schemes have operated without knowledge of the actual genes underlying the traits under selection, and genetic evaluations were entirely based on phenotypic data. In the last 15 years techniques have been developed which enable scientists to detect genes. Molecular markers, small pieces of DNA which can be genotyped easily and used to follow the transmission of chromosomal segments from parents to offspring, are used to identify and map QTLs. With advances in molecular biology, the identification of QTLs is now possible and is likely to lead to more efficient breeding programs. The identification of QTLs can increase the accuracy of selection by providing more information to predict an animal's breeding value. Also, genetically superior individuals can be identified early in life, perhaps even before they are born. This will greatly reduce the generation interval and increase the rate of genetic progress per year.

The variability of timing and duration of breeding, as well as the successful selection for aseasonality indicates that breeding out-of-season is under genetic control (Notter D.R., 1992), but very little is known about the identity of the genes responsible for this genetic variation. Several candidate genes potentially involved in breeding out-of-season are melatonin receptor(s), prolactin, and the genes implicated in the circadian clock.

Several candidate genes potentially involved in milk production traits are the casein cluster (Fitzgerald et al., 1997),  $\beta$ -lactoglobulin (Hill et al., 1997), as well as segments of chromosomes 6 (Spelman et al., 1996) [distinct from the casein locus 14 (Coppieters et al., 1998)] and 20 (Arranz et al., 1998). These candidate genes and chromosomal regions have been identified to affect milk production traits in dairy cattle. In sheep, there is only one study on QTLs influencing milk traits, and this study confirms the presence of a QTL on chromosome 6 (Diez-Tascon et al., 2001).

A project at the Cornell Sheep Farm is being carried out to examine the sheep genome for mutations related to candidate genes and will scan the genome for markers of QTLs likely to increase milk production and to allow aseasonal breeding. The specific objectives of this research are to:

1. Identify QTLs associated with aseasonality and milk production using a candidate gene approach to determine for each gene the allele that results in the most valuable phenotype.
2. Identify QTLs associated with aseasonality and milk production using whole genome screening to localize genes using marker-QTL associations.

## **Experimental Plan**

Two approaches will be used to identify the QTLs. The first strategy will use the candidate gene approach, which consists of studying genes potentially involved in the physiological process. The second method, known as positional cloning, will use markers covering the whole genome to localize the genes affecting the trait of interest using marker-QTL associations. The positional approach is based on mapping QTLs to progressively narrower chromosomal regions, using a series of microsatellite markers.

## **Breeding design**

The basic methodology for mapping QTLs involves using a cross between two breeds that differ substantially in the quantitative trait(s) of interest. An experimental population of animals was created by crossing Dorset ewes from the Cornell Sheep Farm and East Friesian rams from Old Chatham Shepherding Company (OCSC), a sheep dairy near Albany, NY. The Cornell Dorset ewes are non-dairy sheep that have been selected for aseasonality and prolificacy, while the East Friesian dairy breed is known for high milk production but poor aseasonal breeding. The two parental populations are adequate for this project, with one line predominantly likely to carry favorable alleles and the other line predominantly likely to carry unfavorable alleles with respect to the two traits of interest. During August 2000, October 2000, January 2001 and March 2001, 72 F1 rams and 86 F1 ewes were produced. The F1 ewes were purchased by OCSC to be

placed in the milking flock and bred back to East Friesian rams. About 200 backcross animals will be generated to identify QTLs for milk yield using the candidate gene and whole genome scan approach.

Eight F1 rams were used to breed the entire flock of 240 Dorset ewes during the October 2001 breeding season to produce about 125 backcross females in Spring 2002. These females will be used in Spring 2003 to identify QTLs for aseasonality using the candidate gene and whole genome scan approach. Another group of backcross females will be produced in 2003.

### **Measurement of milk production**

Milk production in the East Friesian x F1 backcross ewes will be recorded weekly in the OCSC data base. A genetic evaluation of the OCSC flock was performed by Professor P.A. Oltenacu (Cornell University) and breeding values for milk production for all animals were estimated. A test-day animal model accounting for age and season effects was used. After milk production records are accumulated on the backcross ewes, their breeding values will be computed using the test-day animal model and correlated with candidate gene differences and markers for QTLs to identify potential DNA indicators for selection.

### **Measurement of aseasonality**

Aseasonality in the yearling F1 x Dorset backcross ewes will be determined by measuring progesterone (a spike in blood progesterone indicates that a ewe is in estrus) using four blood samples prior to the start of the spring 2003 breeding season on March 15. Blood samples will be taken twice a week during the last two weeks of February to detect estrus in nonstimulated ewes and again during the first two weeks of March when the presence of vasectomized rams should help to stimulate estrus activity (this is a common management practice). The vasectomized rams will be brisket-painted to leave marks on any ewes that are mounted. On March 15, intact rams (also brisket-painted) will be introduced to the ewes and the ultimate test will be the number lambs a ewe produces in the August-September 2003 lambing season. Whether a ewe lambs and how many lambs she delivers after breeding in March 2003 is a key determinant of aseasonality because there is evidence that part of the aseasonal response is the ability to maintain pregnancy after a spring conception (Pope et al., 1989).

### **DNA collection and processing**

Blood samples will be collected on all the animals in the parental populations and backcrosses shortly after weaning and the DNA will be extracted using a Qiagen kit. Appropriate primers will be used to amplify microsatellite markers to verify parentage of all animals.

Identification of QTLs associated with aseasonality and milk production using a candidate gene approach

Using the information from published marker maps, a panel of microsatellite markers will be identified for each candidate gene (so that the markers are located inside the gene or within 5 cM of the gene). These markers will be tested in all the animals in the parental lines. Only those markers

that are polymorphic (the individuals carry different alleles at each locus) will be used in the experiment. Our goal is to use five to six microsatellite markers for each candidate gene.

The analysis of the candidate genes for aseasonality will be carried out using the animals that result from the F1 x Dorset backcross. These animals will be scored for their genotype at the marker loci for each of the candidate genes and their phenotype for aseasonality. The analysis of the candidate genes for milk production will be carried out using the animals that result from the East Friesian x F1 backcross which will be scored for their genotype at the marker loci for each of the candidate genes and their phenotype for milk production.

Identification of QTLs associated with aseasonality and milk production using a whole genome scan approach

The current genetic linkage map for sheep consists of more than 1800 microsatellite markers of which about 1,000 with known map locations are well-suited for a genome scan (Archibald et al., 2001). About 120 markers placed approximately 20 cM apart throughout the entire genome will be used, which should provide a good chance of detecting QTLs anywhere in the genome. These markers will be tested in all the animals in the parental lines and only those markers that are polymorphic (the parents carry different alleles at each locus) will be subsequently used in the experiment. All the informative markers will then be genotyped in both backcrossed populations (F1 x Dorset and East Friesian x F1).

### **Microsatellite marker genotyping**

The microsatellite markers will be PCR-amplified using fluorescently labeled primers. The samples will be then separated on vertical acrylamide gels and ABI Genescan analysis software will be used to analyze the fragment sizes. The use of fluorescently labeled primers permits the analysis of four different PCR reactions in only one gel lane. Genotyping at the marker loci will be carried out at the Cornell BioResource Center.

### **Data analysis**

Our data will consist of a set of markers genotyped on each individual and values of the phenotypic trait also measured on each individual. Because our markers belong to a linkage map and their position on the map is known, we will use the interval mapping method described by (Lander and Botstein, 1989) in which sets of linked markers are analyzed simultaneously. The method uses maximum likelihood estimation and provides a likelihood ratio test for the presence of a QTL between the markers considered. If there is a QTL effect at a specific location in the genome there will be an association between the trait values and the interval analysis linked to that location.

### **Expected Results**

We expect to identify QTLs that can be used to improve our understanding of the basic biology of reproduction and milk production and to intensify selection for these traits. Identified QTLs will then be used in genetic evaluation programs to select for higher milk production and ability to breed out of season.

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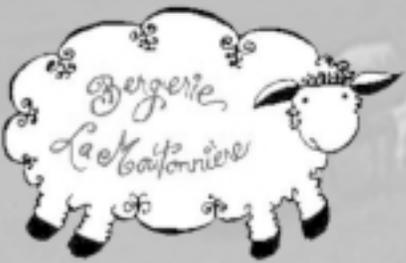
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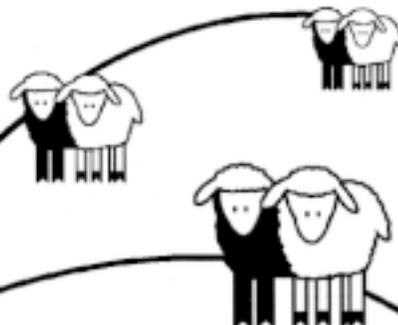
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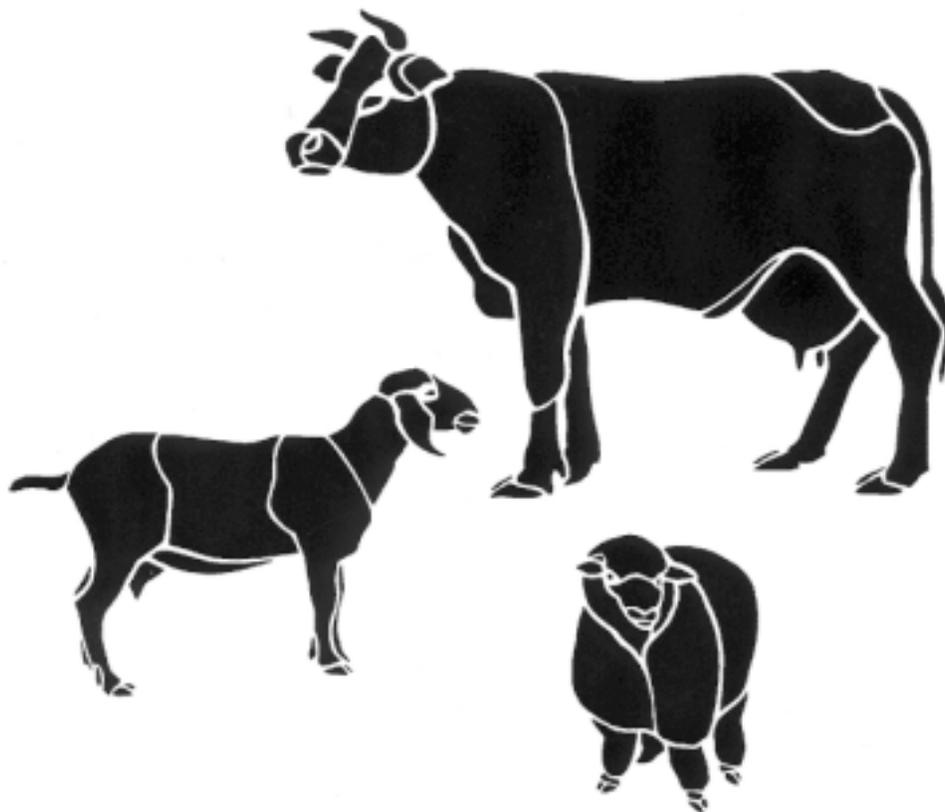
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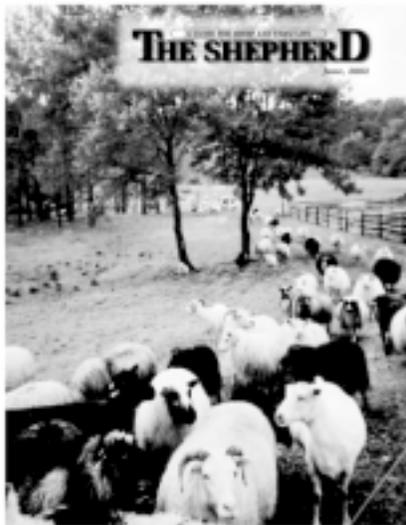
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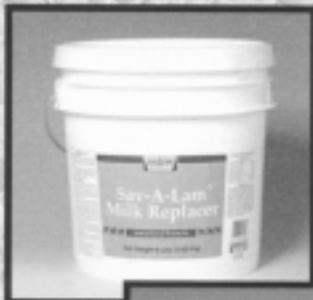
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CATALOG (AVAILABLE NOV. 29)

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## Pladot Mini Dairy

### Miniaturized Dairy Processing Systems



The Pladot Mini Dairy is a miniaturized dairy processing facility that includes all the equipment required to manufacture a very wide variety of dairy products. The facility is tailored to occupy small physical spaces, and is uniquely suited to process smaller lots of more specialized products close to their target markets.

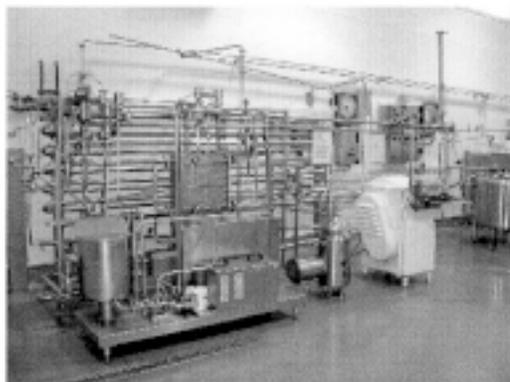
Unlike any other equipment supplier and unlike any other food processing concept, Pladot offers the Mini Dairy as a competitively priced package of equipment, engineering, implementation and training services that reduces the amount of time and size of investment required to develop a small scale dairy processing business.



"We are extremely happy with our mini-dairy yogurt processing plant that we have built with your help, and we are enjoying the experience of shipping whole milk yogurt from our Jersey cows to grocery stores in our region."

*Michelle Weighert, Ph.D. - CC's Jersey Crème, Ltd*

Visit our web site at [www.minicreamery.com](http://www.minicreamery.com)



Pladot brings to the table a total solution. Pladot plans, manufactures, integrates and assembles your Mini Dairy components into a fully functioning processing facility. Pladot's engineers provide the necessary CAD drawings to plan and outfit your building. Pladot's technicians teach you how to operate your equipment and our manufacturing specialists provide you with the necessary training, recipes and food technology expertise required to process a long list of Mini Dairy products. Manufactured of high grade materials to exacting quality specs mandated by the ISO 9000, A-3, UL and CE Standards, Pladot's engineers work with regulatory agencies to insure your Mini Dairy meets licensing criteria and is ready for full scale processing.

Pladot Mini Dairy Kibbutz Ein Harod Meuhad 18965 Israel  
 US Management Office: 301.493.5963 email: [minidairy@comcast.net](mailto:minidairy@comcast.net)  
 Toll Free: 1.888.521.3030 Phone +972.4.648.5090 Fax: +972.4.653.1641  
 Web: [www.pladot.com](http://www.pladot.com) eMail: [pladot@pladot.com](mailto:pladot@pladot.com)

## Dairy Goat & Sheep Headgates



Cascade Yoking System  
 For Dairy Goats and Sheep

- ◆ Simple Self-locking Design
- ◆ Saves Hours of Labor
- ◆ Welded Steel Construction
- ◆ Platform, Ramps, & Gate also available
- ◆ Made in Vermont.

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# CHEESE MAKING

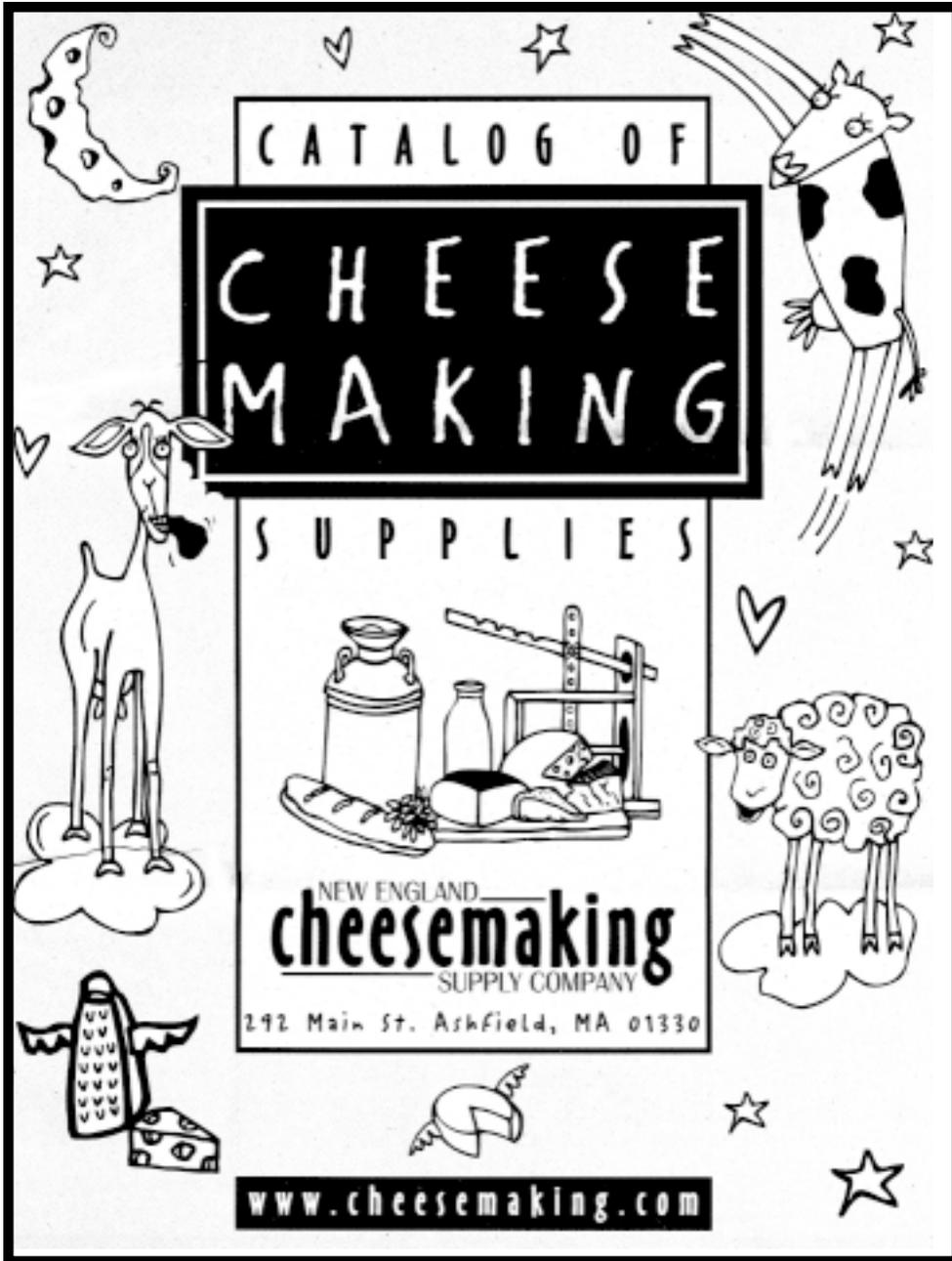
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**Raise your lambs easily and efficiently on milk replacer using one of our automatic feeders and sell more of your valuable ewe milk.**



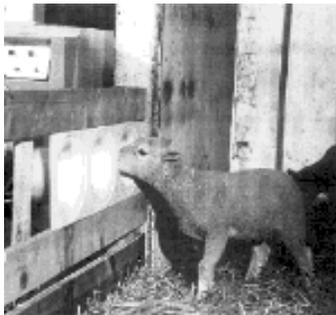
**LAC-TEK**

- Feeds up to 50 lambs
- 25 lb milk powder hopper
- Up to 6 nipples for lambs
- Fully automatic
- 2 gallons water heater
- 110 or 220 volts
- Low price



**NURSOMAT**

- Feeds up to 80 lambs
- 25 lb milk powder hopper
- up to 6 nipples for lambs
- Fully automatic
- 5 gallons water heater
- 110 or 220 volts



Our machines automatically mix milk at a pre-set concentration and temperature and deliver it to up to 6 separate nipples. It mixes on demand. The milk, therefore, is always fresh. A rinsing cycle allows daily cleaning. Daily servicing, including washing and filling the hopper, takes only 5 minutes.

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