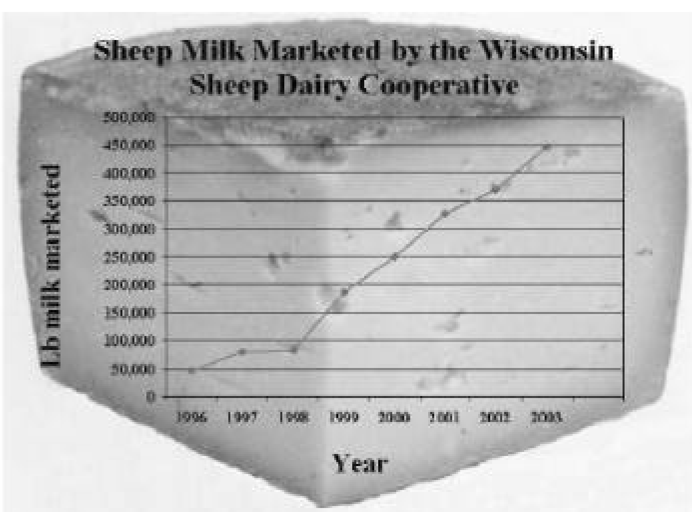
Proceedings of the

10th Annual

Great Lakes Dairy Sheep Symposium

November 4-6, 2004



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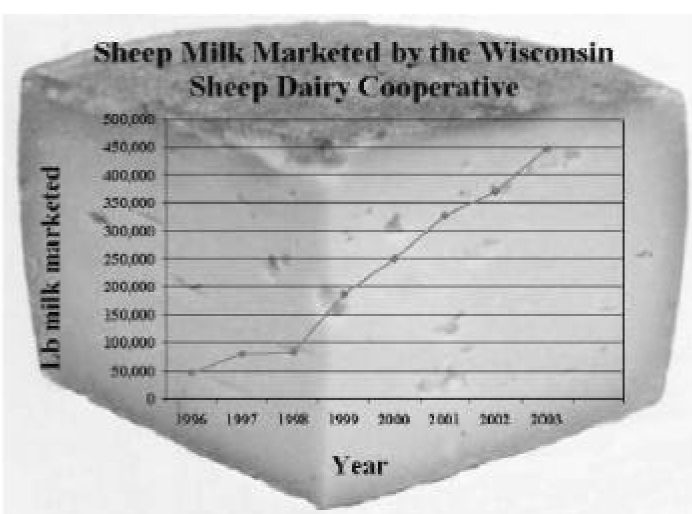

Hudson,
Wisconsin
USA

Proceedings of the 10th Great Lakes

Dairy Sheep Symposium

November 4-6, 2004

Hudson, Wisconsin, USA

Presented By:

The Dairy Sheep Association of North America

Organized By:

The University of Wisconsin-Madison, Wisconsin, USA

Department of Animal Sciences

Spooner Agricultural Research Station

CALS Outreach Services

The Wisconsin Sheep Dairy Cooperative

Organizing Committee

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Alice Henriksen and Dan Guertin, Stillwater, Minnesota, USA
Laurel and Tom Kieffer, Strum, Wisconsin, USA
Emily and Larry Meisegeier, Bruce, Wisconsin, USA

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Bette Granberg, Madison, Wisconsin, USA

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Thursday November 4, 2004

7:30 Registration

8:30 Board Buses

9:00 Beginners and hand on sessions at Dan Guertin and Alice Henriksen's

- How to start a sheep operation *Dan Guertin (producer*)
- How much to invest *Dan Guertin (producer)*
- How many sheep to start with *Dan Guertin (producer)*
- Type of sheep to use *Yves Berger (Spooner Ag Research Station)*
- Different types of milking systems *Pierre Billon (Institute elevage, France)*
- Practical look at pipeline systems *Pierre Billon*
- Pro's and con's of different milking units, pulsators etc. *Pierre Billon*
- Settings of vacuum, pulsation rates, etc. *Pierre Billon*

11:30 Load Buses; Return to hotel

Noon **LUNCH ON YOUR OWN** and **Second Registration**

1:00 Milking system for small and medium size operations

Pierre Billon, Institute de l'Elevage, Le Rhue, France

1:45 Testing, Calculations of yields, Adjustment factors

Yves Berger, Spooner Ag Research Station, UW-Madison

2:30 **BREAK**

2:45 Business or Hobby- Incomes and Expenses

Darlene Eckerman, Tax professional- producer, Antigo, Wisconsin

3:30 Panel of experienced dairy producers to wrap up what has been learned during the day

- Dan Guertin (Producer, Stillwater, MN)
- Tom Kieffer (Producer, Strum WI)
- Larry Meisegeier (Producer, Bruce, WI)
- Pierre Billon (Institut de l'Elevage, Le Rhue, France)
- Moderator: Laurel Kieffer (Producer, Sturm, WI)

4:30 General Assembly DSANA

DINNER ON YOUR OWN

Friday November 5, 2004

8:30 Udder morphology and effects on milk production and ease of

- Dr. Maristela Rovai, Technical University Munich, Germany

9:15 Effect of EF or Lacaune breeding on milk production

- Dr. Dave Thomas, Sheep Extension Specialist, UW-Madison

10:00 **BREAK**

10:15 Effect of feedstuff on milk flavor

- Dr. Scott Rankin, Food Science, UW-Madison

11:00 Residue in milk after use of health treatments

- Dr. Nicole Neeser, Minnesota Department of Agriculture

11:30 Milk composition and cheese yield

John Jaeggi, Wisconsin Center of Dairy Research, U W-Madison

Noon **LUNCH PROVIDED**

1:00 Cultures of specialty cheese production

- Steve Eckerman, CHR Hansen

1:30 Marketing of milk – Problems faced by processors

- Yves Berger (handling milk before shipping)
- Tom Clark (producer-cheese maker, Old Chatham Sheepherding Company, New York)
- Sid Cook (Carr Valley Cheese, Mauston, WI)

2:15 Marketing of cheese –Panel

- Sid Cook (Carr Valley Cheese, Mauston, WI)
- Steven Read (Shepard’s Way, Nerstrand, MN)
- Mary Falk (Love Tree Farm, Grantsburg, WI)

3:30 **BREAK**

4:00 Report on the state of the North American Sheep Dairy Industry

- Dave Thomas, Sheep Extension Specialist, UW-Madison

6:30 Banquet - Entertainment

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8:30 Board Buses for farm tours

- Paul and Sally Haskins, River Falls, WI

LUNCH PROVIDED

- Steven Read, Nerstrand, MN

5:15 Arrive at hotel

Sunday November 7, 2004

(This day is not officially part of the symposium)

Open houses:

Spooner Ag Research Station; Spooner, Wisconsin *

Love Tee; Mary Falk, Grantsburg, Wisconsin *

* denotes that there is no transportation provided

Speakers

Berger, Yves: Spooner Agricultural Research Station, University of Wisconsin-Madison, Spooner, Wisconsin, USA

Billon, Pierre: Institut de l'Elevage, Le Rhue, France

Clark, Tom: Producer-Cheese Maker, Old Chatham Sheepherding Company, New York, USA

Cook, Sid: Carr Valley Cheese, Mauston, Wisconsin, USA

Eckerman, Darlene: Tax professional-producer, Antigo, Wisconsin, USA

Eckerman, Steve: CHR Hansen, Antigo, Wisconsin, USA

Falk, Mary: Producer-Cheese Maker, Love Tree Farm, Grantsburg, Wisconsin, USA

Guertin, Dan: Producer, Stillwater, Minnesota, USA

Haskins, Paul and Sally: Producers, River Falls, Wisconsin, USA

Jaeggi, John: Wisconsin Center for Dairy Research, University of Wisconsin-Madison, Madison, Wisconsin, USA

Kieffer, Laurel: Producer, Strum, Wisconsin, USA

Kieffer, Tom: Producer, Strum, Wisconsin, USA

Meisegeier, Larry: Producer, Bruce, Wisconsin, USA

Nesser DVM, Nicole: Minnesota Department of Agriculture, St. Paul, Minnesota, USA

Rankin, Scott: Department of Food Science, University of Wisconsin- Madison, Madison, Wisconsin, USA

Read, Steven: Producer-Cheese Maker, Shepherd's Way, Nerstrand, Minnesota, USA

Rovai, Maristela: Technical University Munich, Germany

Thomas, Dave: Sheep Extension Specialist, University of Wisconsin-Madison, Madison, Wisconsin, USA

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French Translations of the Summaries

RACES DE BREBIS A UTILISER POUR UNE PRODUCTION DE LAIT COMMERCIALE. Yves M. Berger

Tous les producteurs contemplant la possibilité d'élever des brebis laitières se heurtent au problème du choix d'une race: quelle race ou quel type d'animaux acheter ou élever pour obtenir la production laitière la plus économique? Le problème n'est fas facile à résoudre car aucune race ne combine tous les traits les plus favorables. Certaines races sont plus aptes à la production de lait et d'autres ont des taux de matières grasses ou de protéines plus élevés. Certaines races encore ont une meilleure efficacité alimentaire et d'autres sont plus résistantes à certaines maladies ou parasites. "Mais quelle est la meilleure race?" insiste t-on. Il n'y a pas de meilleure race, ou alors la meilleure race est celle qui plait le mieux au producteur et qui produit suffisament bien en utilisant les resources disponibles dans un environement donné.

QUELQUES CONSEILS POUR PRATIQUER UNE BONNE TRAITE.
P. Billon

La machine à traire fonctionne deux fois par jour pendant toute la durée de la lactation d'un troupeau de brebis. Pendant ce temps, divers éléments peuvent s'user ou se dérégler sans que le trayeur ne s'en aperçoive obligatoirement. En général, les dysfonctionnements de la machine à traire entraînent des accidents de qualité du lait et des infections mammaires.

Pour éviter de tels problèmes, maintenir la machine en parfait état de fonctionnement par une maintenance régulière et un contrôle annuel sont deux conditions nécessaires qui peuvent être réalisées par l'éleveur et par l'installateur.
Cependant, une bonne machine à traire n'est pas une condition suffisante pour éviter tous les problèmes. Le trayeur a aussi un rôle fondamental à jouer en adoptant une technique de traite efficace notamment sans entrée d'air au moment de la manipulation des faisceaux trayeurs et en évitant la surtraite, sans oublier les mesures d'hygiène les plus élémentaires.

LES DIFFERENTS ASPECTS DES MACHINES A TRAIRE DE PETITE ET MOYENNE TAILLE POUR BREBIS LAITIERES.
P. Billon

La norme de construction et de performances des machines à traire (ISO 5707) s'applique aux petits ruminants, et en particulier aux brebis, uniquement pour les recommandations de type qualitatif. Des recommandations d'ordre quantitatif ont été proposées par un groupe d'experts internationaux au sein de la Fédération Internationale de Laiterie (F.I.L.) et on été publiées dans un bulletin de la FIL en 2002. Les recommandations spécifiques pour les brebis portent d'abord sur la détermination de la capacité de la pompe à vide et la notion de Réserve Réelle. Pour les brebis, et contrairement aux vaches, elle est fonction, du type de faisceau trayeur utilisé et du nombre de trayeurs, mais aussi du type de machine (pots à terre ou lactoduc) et du nombre de postes de traite. La capacité de la pompe à vide doit aussi tenir compte des besoins en air pendant la phase de nettoyage (uniquement pour les installations avec lactoduc). De plus, la régulation du vide doit être assurée dans les meilleures conditions afin de permettre un vide le plus stable possible pendant la traite dans toute l'installation.

Les caractéristiques de pulsation chez les brebis sont les suivantes : 150 à 180 cycles/min avec un rapport de 50%. Elles ont une influence directe sur la stimulation de l'éjection du lait.

La détermination du diamètre intérieur du lactoduc est basée sur le même principe que pour les vaches en tenant compte des cinétiques d'émission du lait des brebis et en particulier celle de la race East-Friesian et également du type de faisceau trayeur utilisé.

Enfin, le choix du faisceau trayeur (griffe et manchon trayeur) est abordé à travers des récents enregistrements réalisés en laboratoire tenant en compte l'évolution du niveau de vide sous le trayon et les mouvements du manchon pendant la traite.

CONTROLE LAITIER, CALCUL DE LA PRODUCTION LAITIERE ET FACTEURS DE CORRECTION.
Yves Berger et Dave Thomas.

L'amélioration de la production laitière par la sélection n'est possible quand connaissant la production individuelle de chaque animal. Même dans les petits troupeaux où l'éleveur a une connaissance intime de ses animaux, l'estimation de leur production est très souvent inexacte. Pourtant, quand il s'agit de choisir des agnelles de renouvellement, d'éliminer les brebis les moins productrices, de choisir ou vendre des jeunes béliers, le producteur a besoin d'informations exactes. La seule facon de les obtenir est de pratiquer le contrôle laitier à certaines périodes au cours de la lactation. L'estimation de la lactation ainsi obtenue sera corrigée en fonction de l'âge de l'animal, du système de sevrage pratiqué et de la longueur de la lactation afin de pouvoir comparer tous les animaux entre eux au sein du même élevage. Le système demande un certaine volonté de la part de l'éleveur pour acquérir le matériel nécessaire ou pour utiliser les services d'un organisme profesionnel tel que le DHIA (Dairy Herd Improvement Association).

AGRICULTURE ET IMPOTS – EST-CE UNE ENTREPRISE OU UN PASSE-TEMPS?
Darlene Eckerman.

Qu'est ce qui est venu le premier? La ferme, les moutons ou le rêve? Avez-vous reu une éducation d'affaire ou plutôt agricole? Est-ce votre travail principal, secondaire ou même tertiaire? Quels sont vos plans et objectifs à long terme? Avez-vous un plan d'affaire? Avez-vous des projections à court terme, sur 5 ans, sur 10 ans? Faites vous cela parceque vous aimez bien ou parceque vous êtes fort dans ce domaine? Savez vous que la majorité des nouvelles entreprises ferment leur porte au cours des deux premières années? Non pas parceque le talent n'est pas là mais parceque la bureaucratie et les règles gouvernemantales sont telles qu’un néophyte ne s’y retrouve plus. L’agriculture est une entreprise et doit être conduite en tant que telle. Les besoins de classement et d’enregistrement sont similaire et les mots “agriculture” et “entreprise” deviennent interchangeables.

Les règles comptables aux Canada et aux Etats-Unis sont suffisament similaires pour que la plus grande partie des informations données dans cet article s’appliquent aux deux pays. Les différences sont notées et référenciées aux publications appropriées. Les informations sont applicables à votre élevage de brebis laitières et/ou à votre entreprise de transformation et vente de produits laitiers.

MORPHOLOGIE DE LA MAMELLE, EFFETS SUR LA PRODUCTION LAITIERE ET FACILITE DE TRAITE CHEZ LA BREBIS LAITIERE.
Maristela Rovai, David L. Thomas, Yves M. Berger et Gerardo Caja.

On accepte généralement la morphologie de la glande mammaire comme le facteur principal de la facilité de traite et son inclusion dans les schémas de sélection est vivement recommandée. Les caractéristiques anatomiques et morphologiques de la mamelle ainsi que leur relation avec la production laitière, la facilité de traite et la conduite générale du troupeau ovin laitier sont devenus du plus grand intérêt pour l’éleveur ainsi que pour le chercheur. La mamelle de la brebis est une glande épithéliale exocrine constituée principalement d’un parenchyme tubulo-alvéolaire avec des alvéoles et des citernes très différenciées. Alvéoles et citernes sont considérées comme les deux compartiments anatomiques permettant le stockage du lait; les brebis ayant les citernes les plus larges sont généralement celles ayant une meilleure production laitière. L’évaluation de la morphologie de la mamelle par mensuration , pointages linéaires et typologie est discuté dans cette article. Une méthode moderne utilisant les ultrasons a été utilisé pour étudier la glande mammaire et les capacités de stockage de celle-ci. La facilité de traite a été évaluée par l’étude des courbes d’émission du lait au cours de la traite. Les deux critères (stockage et facilité de traite) sont discutés et analysés pour des races à niveaux de production différents. Les corrélations phénotypiques et génétiques indiquent idiquent une détérioration de la morphologie de la mamelle lorsqu’une sélection pour une meilleure production laitière est pratiquée, résultant en des mamelles inadéquates pour la traite à la machine. Les caractéristiques des trayons et de la citerne sont les critères les plus limitants d’une bonne facilité de traite à la machine. Une certaine sélection sur les caractères morphologiques de la mamelle devrait être pratiquée ainsi que l’utilisation des pointages linéaires. Il serait désirable de connaître la relation entre la morphology de la mamelle et la production laitire et facilité de traite des brebis laitières américaines afin de pouvoir donner aux éleveurs des recommendations adéquates. L’efficacité du sytème européen de pointage pour les brebis croisées viande-lait américaines y est aussi discuté.

EFFETS DE L’ UTILISATION EN CROISEMENT DES RACES OVINES FRISONNE DE L’EST OU LACAUNE SUR LA PRODUCTION LAITIERE.
David L. Thomas, Yves M. Berger, Randy G. Gottfredson, and Todd A. Taylor.

La comparaison des races ovines laitières Frisonne l’Est et Lacaune fut initiée en1998 dans un système de production ovine laitière typique du Midwest Américain. Les accouplements furent choisis de faÿon à produire des groupes à haut pourcentage Frison, des groupes à haut pourcentage Lacaune et des groupes de croisés à pourcentage varié Frisonne de l’Est –Lacaune. Cet article résume les resultats obtenus de 1998 à la fin de l’été 2004. Les résultats montrent qu’en remplaÿant 50% Frisonne par 50% Lacaune le nombre d’agneaux nés pour 100 brebis est diminué de 15, que la production laitière est légèrement plus faible (~7%) et que les pourcentages de matière grasse et p rotéine sont augmentés respectivement de 0,3 et 0,6 point. Un programme de croisement rotatif avec des brebis Frisonne de l’Est et des béliers croisés F1 Frisonne-Lacaune est suggéré. Ce système de croisement permettrait d’avoir un troupeau constitué de la moitié des brebis 83% Frisonne, 17% Lacaune et l’autre moitié de brebis 67%Frisonne et 33% Lacaune.

EFFET DE L’ ALIMENTATION SUR LES GOUTS DU LAIT.
Valerie Kurba et Scott Rankin.

Le gout du lait est composé d’une variété de composés chimiques en provenance de plusieurs sources. Certains composés trouvés dans le lait sont directement liés au régime alimentaire des animaux produisant le lait. Dans beaucoup de cas l’origine de ces composés est uncertain. Deux hytothèses principales sont avancées: ou bien les composés ont leur origine dans les plantes ingérées par l’animal ou ils sont les produits de la digestion de précurseurs. Des aliments du bétail assez commun comme le TMR (Total Mixed Ration), herbage, maïs et foin, et leur combinaison possible, peuvent influencer le gout du lait ainsi que sa composition. D’autres aliments peuvent affecter les performances de production de l’animal. En général, les vaches recevant un TMR ont une production laitière, un poids et une condition corporelle supérieurs aux vaches en herbage. Le lait des vaches nourries à l’herbe a en général plus de composés influenant le gout que les vaches recevant un TMR.

RESIDUS DANS LE LAIT APRES TRAITEMENTS SANITAIRES DES ANIMAUX.
Nicole Neeser.

Malgré tous les efforts mis sur la prévention des maladies dans un troupeau de brebis laitières, certaines brebis tomberont malades et des traitements sanitaires seront nécessaires. Dans plusieurs instanses ces traitements nécessiteront des drogues qui laissent des résidus dans le lait après leur utilisation. La règlementation des résidus de drogues et de l’utilisation de drogues sur les animaux destinés à l’alimentation humaine est parfois difficile à comprendre et à interpreter. Les éleveurs de brebis laitières doivent cependant suivre les même règles que les éleveurs de vaches ou chêvres laitières. Il est important d’éviter les résidus de drogues aussi bien pour maintenir la qualité et le gout des produits que pour prévenir les problèmes de santé humaine.

COMPOSITION DU LAIT ET RENDEMENT FROMAGER DANS LA FABRICATION DE FROMAGES FRAIS ET PRESSES AVEC DU LAIT DE BREBIS.
John J. Jaeggi, William L. Wendorff, Mark E. Johnson, Juan Romero and Yves M. Berger.

Du lait de brebis de début, milieu et fin de lactation fut utilisé pour la fabrication de fromages frais et durs. Le taux de matières grasses dans les fromages n'est pas modifié par le stade de lactation alors que le taux de proteines est plus elevé dans les fromages fabriqués avec du lait de milieu de lactation. Le rendement fromager est meilleur avec du lait de début de saison qu'avec du lait de milieu ou fin de lactation de calcul de rendement fromager peut être utiliser pour estimer le rendement fromager du lait de brebis.

CHOIX DES CULTURES POUR LA FABRICATION DE FROMAGES.
Steve Eckerman

Le choix d'une culture est une étape importante de la fabrication du fromage. Différentes cultures sont utilisés pour différents types de fromage. Les cultures sont choisies aussi en fonction du style de fromage, du matériel de fabrication et même en fonction de l'emballage. Les cultures commerciales sont généralement du type Lactococcus ou Steptococuss mais d'autres types sont aussi utilisés. Cet article grâce à des taux de matières sêches utiles plus élevés. Les taux de matières grasses, proteines et solides dans les fromages permettent d'assurer que la formule Van-Slyke discute de la sélection de différentes cultures, de leur dévelopement et de leur effet sur la fabrication et l'affinage du fromage ainsi que la raison des démarrages lents.

Le choix de la culture est en fonction de plusieurs considérations. Une d'entre elle est la température à laquelle le fromage est fabriqué ainsi que les températures minimum et maximum. Une autre considération par example est la formation de gaz pour laquelle des cultures spécifiques sont nécessaires. Les cultures doivent aussi respecter les contraintes de sel et les effets de protolysis and lypolysis.

L'UTILISATION DU LAIT DE BREBIS CONGELE – PROCEDURES ET DIFFICULTES RENCONTREES.
J. Thomas Clark.

La Old Chatham Sheepherding Company utilise depuis plusieurs années une quantité significative de lait de brebis congelé. Au cours des années la companie a mis au point des recettes à succès utilisant un mélange de lait congelé et de lait frais pour ses yaourts et certains types de fromages. La difficulté dans l'utilisation du lait congelé réside surtout dans l'augmentation des coûts: congélation, stockage, transport et décongélation. Il y a aussi des pertes dans la fabrication avec le lait congelé dont la cause est difficile à déterminer. Des recherches supplémentaires sont indispensables pour déterminer des méthodes de contrôle de qualité assurant que le lait ait été congelé et stocké à des températures adéquates ainsi que de déterminer la longévité du lait congelé. De plus, une meilleure technique de décongélation doit être développée. Le marché du yaourt et du fromage fait au lait de brebis se développe rapidement. Améliorer la fiabilité de l'utilisation du lait congelé permettrait aux producteurs de tous niveaux d'augmenter leur production et leur vente.

ACHETER DU LAIT DE BREBIS – PROBLEMES RENCONTRES PAR LES TRANSFORMATEURS.
Sid Cook.

Dans les cinq années que nous avons acheté du lait de brebis nous nous sommes heurtés aux problèmes suivants:

1. Méthodes de manutantion et de transport.
2. Les quantités de lait.
3. Les variations de la qualité des composants du lait au cours de la saison et l'effet sur le rendement.
4. L'inventaire et l'affinage des fromages de lait de brebis.
5. Soucis de qualité du lait.

NOTRE PREMIERE GROSSE VENTE DE FROMAGE!!!!!
Mary Falk

J'espère que tout le monde tolèrera ma petite histoire de NOTRE GRANDE VENTE DE FROMAGE!!!! Quand je voie que je digress un petit peu de l'article typique sur le marketing. J'ai décidé de partager avec vous une vrai histoire un tant soit peu embarassante, en pensant que les points principaux de marketing deviendraient plus Linteressants quand racontés sous une forme réel au lieu du charabiat académique. J'ai souligné en caractères gras les principaux points de marketing qui préoccupent un petit fabricant artisanal de faon que chacun puisse parcourir l'article rapidement et retenir seulement l'intéressant. En aucun cas cet article prétend inclure tous les secrets du métier, car il n'y en a pas.

Avoir du succès dans la vente de fromages artisanaux est vraiment tout bête: en utilisant les meilleurs produits de base et en donnant le meilleur de soi-même, le fromage se vendera tout seul. Le seul problème c'est que le fromage ne peut pas conduire, vous devez donc pouvoir vous déplacer.

'ETAT DE L'INDUSTRIE LAITIERE OVINE EN AMERIQUE DU NORD.
David L. Thomas.

La production laitière ovine au Canada et aux Etas-Unis a démarré il y a environ 25 ans. Les races principales sont la Frisonne de l'Est et la Lacaune avec quelques British Milksheep au Canada. La production totale en 2003 a été estimé entre 1,2 et 1,8 millions de kilos produits par 10000-11000 brebis de 65-75 fermes. Approximativement 50% des fermes transforment leur lait en fromages artisanaux fermiers. Une grande majorite du lait vendu aux fromageries commerciales est congelé à la ferme et transporté congelé jusqu'à la fromagerie. L'Association Nord Americaine des Eleveurs de Brebis Laitières (DSANA) fut formée en 2002 pour aider au dévelopement de cette nouvelle industrie.

BREEDS OF SHEEP FOR COMMERCIAL MILK PRODUCTION

Yves M. Berger
Spooner Agricultural Research Station
University of Wisconsin-Madison, Madison, Wisconsin, USA

Any producer contemplating the prospect of sheep dairying will face the problem of breeds: which breeds or what type of animals to purchase (or develop) in order to have the most economical commercial milk production? The problem is not an easy one to solve because there is not a single breed that combines all favorable traits. Some breeds are better than others in producing milk and others are better in milk components (fat, protein, solids). Some breeds are more efficient feed converters and others give their milk more easily. Some breeds are more sensitive to the environment and others are more resistant to diseases. “What is the best breed, though?” many insist on asking. There is no best breed; there is only a breed that fits best the personal preferences of the owner and a breed that will produce reasonably well with the resources of a particular environment.

Domestic breeds

Beginning in 1984 several U.S. sheep breeds were evaluated at the University of Minnesota for milk production potential. Ewes were chosen from available breeds and machine milked twice a day following weaning of their lambs at 30 days of age. Ewes were subsequently milked for 120 days. The performance of these breeds over a two year period for milk production and milk composition is shown in table 1. With the exception of the Finn and Romanov breeds, all other domestic breeds studied seem to have a simular potential for commercial milk production. The average daily milk production of all ewes was .47 kg per day. With such a low production, one wonders if these breeds can be milked economically. An indication that they might not is that the early pioneers of sheep dairying in the U.S. were using popular breeds such as Polypay and Dorset in their first attempt at milking. They were soon looking for ways to rapidly improve their average production. It is not to say, however, that these breeds should be disregarded all together. They have certain advantages that the more dairy type breeds might not possess such as: good adaptation to a wide array of environments, good lamb and/or wool production, ability to breed out of season (Polypay, Dorset), known behavior, and widely available at a reasonable price. By careful selection, their overall production could increase dramatically. Jordan and Boylan (1988) suggest that by mass selection and screening of the best milking ewes, overall milk production could increase by 30 to 40% in just a few years.

A lower milk production could be quite acceptable in some segments of the industry. It is well known that there exists a strong negative correlation between the total amount of milk and the percentage of fat. Generally, the higher the production the less fat there is in the milk. In order to produce a very high quality sheep milk cheese, the milk needs to be high in butterfat (6-8%). Domestic breeds producing a moderate amount of milk do have higher butterfat content. If the dollar value of the milk is clearly dependent on its quality (fat and protein, the sum of them being the total useful dry matter) the discrepancy in terms of milk yield between a pure dairy breed such as the East Friesian and a domestic breed is much reduced in terms of overall return per ewe.

Table 1. Least-squares means for several milk traits by breed (1989-1990). Milking period only.

Breed	Milk in liters (pounds)	Fat (%)	Protein (%)	Lactose (%)	Solids (%)
Overall mean	57 (130)	6.6	5.8	4.7	17.9
Suffolk	69 (157)	6.7	5.9	4.7	18.1
Finnsheep	44 (100)	6.1	5.5	4.5	16.7
Targhee	62 (141)	6.9	5.9	4.8	18.4
Dorset	61 (139)	6.3	5.7	4.5	17.2
Lincoln	53 (121)	6.8	5.8	4.7	18.0
Rambouillet	65 (148)	6.6	6.1	4.9	18.3
Romanov	44 (100)	7.1	5.9	4.8	18.6
Outaouais	54 (123)	7.3	6.1	4.6	18.7
Rideau	77 (176)	6.6	5.8	4.8	18.0

W.J. Boylan (1995)

The East Friesian (Ostfriesisches Milchschaf)

This breed of sheep is now readily available in the United States. Many entrepreneurs in Canada or the US are selling live animals, embryos or semen of different origins mainly from England, Holland, and Sweden (through New Zealand).

The East Friesian is considered one of the best milking sheep in the world. Average production of 450-500 kg per lactation of 220-240 days and more have been recorded. It has, however, one of the lowest fat and protein contents (5.5-6.5% and 5% respectively), and the increase in fat content during the lactation is very small (1 to 2%). The lower fat and protein content is somewhat detrimental for the production of high quality sheep milk cheese entirely dependent on fat and protein for yield, flavor and texture. To the best of our knowledge, there is no selection program in place on the East Friesian in the countries of origin. The purchase of semen (or live animals) from Europe shows a certain degree of heterogeneity in the quality of the animals.

Prolificacy of 230% has been reported making this breed one of the most prolific breeds. At The Spooner Agricultural Research Station, University of Wisconsin-Madison, Berger (1998) reports prolificacy of 200% on 12 month old and 230% on adult crossbred ewes. With their high milk production and high prolificacy, the East Friesian breed is an efficient lamb producer. Although it has a rather poor carcass conformation, lambs produced from crossbreeding with a terminal breed such as Suffolk, Hampshire or Texel have a remarkable growth with desirable carcass traits.

The East Friesian has a rather short breeding season starting 12 to 18 weeks after the longest day of the year. The best breeding period would be between September and November. Ewe lambs are precocious enough to be bred successfully at 7 to 8 month of age.

There is no doubt that by using the East Friesian in a crossbreeding system, a spectacular improvement can be achieved very quickly. An average milk yield of 160-180 liters (350-400 pounds) per ewe can be obtained very quickly after starting with an original flock of Dorset type ewes as observed at the Spooner Agricultural Research Station.

Milk production of 1, 2, and 3 years old ewes is shown in Table 2. East Friesian cross ewes have a lactation length 30 to 40 days longer than Dorset type ewes and produced more than twice as much milk. Fat and protein percentage of milk from Dorset type ewes is approximately 0.5 percentage units higher compared to milk from EF-cross ewes. No difference can be found between milk production and fat and protein percentages between ewes of different EF percentage. 50% EF ewes did not produce more milk than 25% EF ewes.

In North America, the desired level of EF breeding in commercial dairy ewes; however, still needs to be determined. But it seems that a high level of EF is not necessary to achieve high level of production. A high level of EF might result in lower productivity due to a lower degree of adaptability to a new environment and to a higher incidence of health problems if not managed to a high standard.

Table 2. Milk production of Dorset-cross and EF-cross ewes.

Breed	Age	Number of ewes	Milking period only (days)	Total milk (kg)	% Fat	% Protein
Dorset-cross	1	73	79 ± 5	62 ± 9	5.9 ± .6	5.3 ± .05
	2	43	94 ± 7	91 ± 12	5.5 ± .7	5.8 ± .10
¼ EF-cross	1	124	112 ± 4	139 ± 7	5.5. ± .4	5.1 ± .04
	2	92	152 ± 5	206 ± 8	5.1 ± .5	5.4 ± .04
	3	35	173 ± 7	246 ± 13	5.3 ± .7	5.1 ± .07
3/8 EF-cross	1	69	101 ± 5	122 ± 9	5.3 ± .5	5.1 ± .05
	2	40	146 ± 7	190 ± 11	5.0 ± .7	5.3 ± .07
	3	13	160 ± 12	250 ± 21	5.1 ± .5	5.2 ± .10
½ EF-cross	1	71	99 ± 5	128 ± 9	5.1 ± .5	4.9 ± .04
	2	16	145 ± 11	187 ± 18	5.0 ± 1.1	5.4 ± .10
	3	12	178 ± 12	250 ± 22	5.0 ± 1.3	5.1 ± .10

Berger, 1996, 1997, 1998

The Lacaune

The Lacaune was introduced in the United States in 1998 by the Spooner Agricultural Research Station, University of Wisconsin-Madison with the importation of two Lacaune rams from Canada and frozen semen from Great Britain.

The Lacaune is the most important sheep dairy breed in France with 800,000 ewes being milked mostly for the production of Roquefort cheese. It is important to note that before 1965, the Lacaune breed, although used traditionally as a milking animal, could not be considered as a "dairy" animal. With the advance of milking technique (milking machine) and its expansion in the 1960's and the high demand for sheep milk products an intense selection program was started. The milk production of the Lacaune breed increased from 80 liters to 270 liters in about 30 years. The milk production for the Lacaune breed in France, **always** refers to a **milking period of only 165 days** excluding the suckling phase. In 1985, fat and protein content was added to the selection program to enhance the cheese making properties of the milk. In 2001, the selection scheme started to include the resistance to sub-clinical mastitis and udder morphology.

The adult Lacaune has an average prolificacy of 170 to180% with a rather long breeding season starting early (June-July) making it an ideal breed for late fall or early winter lambing. Ewe lambs can be bred very successfully at the age of 7 to 8 months and have a polificacy of 140%.

Studies at the Spooner Station show that the Lacaune is as good as the East Friesian to improve the milk production of other breeds when used in crossbreeding and that their milk has a higher butterfat content. The number of lambs born, however, is significantly lower.

At the time of the writing of this article (August 2004), the future of the importation of Lacaune semen in the United States is uncertain. Direct importation from France is not possible as long as USDA-APHIS does not revise the health requirements stated in the 1995 protocol of importation of ovine semen from France.

The Awassi

The Awassi can be considered a true dairy breed but it is not available in North America. The Awassi is a common dairy breed in Turkey, Syria and Israel. The improved Awassi found in Israel is capable of production of 300 to 350 kg in 200 days with high butterfat content. The prolificacy is low (120-130%) and would significantly reduce the lamb production. Frozen semen of the improved Awassi is available from New Zealand and Australia.

This breed is very well acclimated to a hot and dry climate and could be very valuable in some areas of North America.

Other breeds

Some producers in North America are using other breeds such as the British Milksheep or the Icelandic. Very little comparative information is available on their ability as milk producers. Their importance for the dairy sheep industry cannot be assessed at the present time.

Lacaune x Dorset crossbred ewe lambs

East Friesian x Dorset crossbred ewe lambs

Conclusion

Domestic breeds generally do not produce enough milk when milked with a milking machine to be economically viable as dairy animals. However, because of large differences between individuals of the same breed it seems that the overall production could be fairly quickly improved with intense selection. The quickest way, however, to obtain an economically level of viable milk production is to cross any domestic breed with a breed such as the East Friesian or the Lacaune. Both breeds are specialized diary breeds, and both are available in North America. The percentage of dairy breed does not need to be large to have a significant increase in production. Crossbreeding with East Friesian increases the milk production, decreases the fat content of the milk and increases the lamb production. Crossbreeding with Lacaune results in a similar increase in milk production, increases the butterfat content and reduces the number of lambs born.

The use of either breed, East Friesian or Lacaune, as purebred or in a crossbreeding system with any other breed, seems unavoidable for the production of a sufficient amount of milk in order to be profitable.

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SOME ADVICE FOR A GOOD MILKING

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Abstract

The milking machine works twice a day during the whole lactation of a flock. During this time, some components may wear or may go wrong. Generally, it is very difficult for the milker to notice these troubles. Often, such issues lead to bad milk quality and udder infections.

In order to limit accidents regular maintenance of the machine and checking once a year need to be done both by the farmer and the dealer.

However, a machine in good order is not the only condition to get milk of good quality and to maintain animals in good health. The operator is essential. A good routine avoiding air entering into the installation when handling units and over milking is also a condition of success. Hygiene is also an important factor.

Résumé

La machine à traire fonctionne deux fois par jour pendant toute la durée de la lactation d'un troupeau de brebis. Pendant ce temps, divers éléments peuvent s'user ou se dérégler sans que le trayeur ne s'en aperçoive obligatoirement. En général, les dysfonctionnements de la machine à traire entraînent des accidents de qualité du lait et des infections mammaires.

Pour éviter de tels problèmes, maintenir la machine en parfait état de fonctionnement par une maintenance régulière et un contrôle annuel sont deux conditions nécessaires qui peuvent être réalisées par l'éleveur et par l'installateur.

Cependant, une bonne machine à traire n'est pas une condition suffisante pour éviter tous les problèmes. Le trayeur a aussi un rôle fondamental à jouer en adoptant une technique de traite efficace notamment sans entrée d'air au moment de la manipulation des faisceaux trayeurs et en évitant la surtraite, sans oublier les mesures d'hygiène les plus élémentaires.

Introduction

The milking machine works twice a day during one or two hours and during the whole lactation of the flock. During this working time, some components may wear or may go wrong, and it is not easy for the milker to notice these troubles because the machine still works. Alarm will be sounded by bad milk quality or a high new infection rate.

Main problems can be avoided by a good milking routine and a good organization of the milker. In addition, a regular maintenance of the machine is absolutely necessary.

This document is a guideline for using the milking machines in the best conditions and gives some advice for the maintenance of the machine.

Before Milking

The operator washes his hands and forearms carefully and wears specific clothes only used for milking.

Then he **prepares the machine**. Units have to be placed on their holder ready for use. When using buckets, they are located at the right place and the milker verifies that everything is OK: no cracked or perforated hoses, no twisted liners. He shuts clamps if necessary.

In case of a milking parlour, in addition, he verifies if the milkline and the receiver are well drained and moves the delivery line from the cleaning position to the bulk tank.

Then, the **vacuum pump is switched on**. The operator gives a look to the vacuum gage in order to ensure that the right vacuum level is reached, and he listens for any important leakage coming from opened clamps, disabled hoses or worn material. The pump must run at least 10-15 minutes before the beginning of milking in order to reach the right temperature.

All products and tools that are needed during milking must be ready, close to the milker. It is essential for the operator to avoid bending at the waist during milking in order to pick up towels or different tools or products he needs or when attaching or detaching units.

During Milking

Some milkers apply udder hygiene very similar to the one for cows. It is better to use **wet towels** (**one for each ewe** is an imperative rule). The teats are washed with the towel, then this materiel is wringed, and the udder is dried with the opposite side of the towel. This is a good technique but it is time consuming and can only be used when milking a small number of animals or only for dirty ewes. Another technique is to wash the teats and the base of the udder with running water and to dry with a specific paper. This solution is time and water consuming and is not very popular for milking ewes. The last technique which can be advised is pre-dipping teats with a specific disinfectant product. It is less time consuming but more expensive. Recent research in goat husbandry showed a positive effect on reduction of new infection rates but was dependent on the initial infection level of the flock. Pre-dipping can also be replaced by a towel soaked with a specific disinfectant. These two last techniques must only be used on non dirty animals.

In the huge majority of situations (in Europe), no hygiene is applied to the udder on dairy sheep before milking. Then the milker has only to attach teatcups. This is a fundamental and non evident task. The only thing to do is **to put on rapidly the two teatcups on the teats without any air entry into the installation**. Influence of air into the plant is explained in the other paper I have prepared for these proceedings; ("The designing of small and middle sized milking installations for dairy sheep"). It is easy when using special clusters with automatic teatcup valves. This is why they are strongly recommended, especially for new milkers.

When using a conventional cluster, usually operators introduce their two thumbs into the mouthpieces of the liners when detaching from the previous animal and then move to the adjacent ewe ready to be milked (or to the opposite platform) and put the two teacups simultaneously on the two teats. This technique leads to more risks and can produce large irregular vacuum fluctuations under the teat especially if the vacuum pump cannot compensate for the totality of air entering into the installation. Despite this drawback, this technique is very popular in France and other countries close to the Mediterranean Sea where diary sheep have been kept for ages.

When all clusters are attached, the **milker has to be free** in order to ensure that animals are being milked properly. He must be ready to readjust teatcups rapidly if a liner slips and/or to reattach a milking unit after a fall-off. Then he has to look at every udder in order to be ready to detach each cluster as soon as possible when milking is finishing in order to avoid over-milking. For example, if the average milking time per ewe is 2 minutes and the average total time spent during the different tasks is 30 seconds, the operator will be able to work with only 4 units. Decreasing working time per ewe leads to the possibility of more units per operator. In large milking parlours automatic teatcup removers are very useful tools.

Be careful! Hard stripping is generally not necessary. The amount of machine stripping depends on the morphology of the udder and the location of teats. Sometimes it is necessary to lift the base of the udder in order to empty its lower part. Generally, only 10 to 20 seconds of machine stripping are necessary. On the contrary, deep massaging of the udder everywhere during the two minutes/or more of milk is totally not necessary and results in bad habits of the animals (eg. slow milk down) and produce udder troubles. It is important to keep in mind that the stimulation of the udder just before milking when washing teats or by the milking machine itself, thanks to adequate adjustments of pulsators and vacuum, should be adequate to properly stimulate the animal for oxytocin release and milk let down. If stimulation is not good, milk still remains in the upper part of the udder, in the acini, and it is always very difficult to get it. High pulsation rates are known for inducing a good reflex of milk ejection in dairy sheep milking machines.

Just after the milking units are detached, teats can be dipped in a disinfectant product. This technique is not common in dairy sheep husbandry because it is time consuming and products are not very cheap. However, it can be advised in particular cases where an abnormal number of clinical mastitis cases is observed in a given flock.

After Milking

Immediately after milking, all surfaces in contact with milk during milking must have residues removed and be cleaned.

With bucket milking machines, milking units can be cleaned with a simple automatic system; it is more efficient and easier than manually. However, buckets themselves must be cleaned manually with brushes and detergent (in order to remove fat, protein and lactose residues) and disinfectant (in order to remove bacteria still remaining on surfaces). Please don't use worn brushes which scratch stainless steel.

Machines milking with milklines: Cleaning in Place is recommended.
The cleaning process is at least :

- pre-cleaning with tepid water (not greater than 50°C or 122° F) in open circuit,
- cleaning with a solution of detergent and disinfectant (circulation for 8-10 minutes maximum),
- rinse with cold water in open circuit.

In addition, **tartar has to be removed** with specific products (acids). Acid cleaning frequency depends on the level of calcium in water.

Obviously, **external parts** of each component has to be cleaned with running water and brushes after each milking, especially the clusters and buckets. Don't forget to clean the lines of the milkline and stalls; once a week for example.

Platforms and corridors must also be kept clean. At least they have to be swept up after each milking and washed with running water once a week.

Filters must be thrown in the bin. Filters which can be reused must be dismantled, manually rinsed, and put in the wash trough to be cleaned with the same process as the milking machine.

Maintenance

A milking machine for dairy sheep works twice a day during more than 7 to9 months. Thus it has to be in a good order every time it is used during the entire lactation of the flock.

To succeed and to avoid milk quality and/or udder health issues, it is essential to have a good **maintenance** of every component of the plant. Two people at least are actually involved: the **farmer and the dealer**.

Following are the different maintenance required for each component.

Vacuum pump

- **Once a week**: verify the oil level in the container and if needed add oil **(farmer).**
- **Every 3 months**: verify the tension of the driving belt and clean external parts of the pump (remove dust) **(farmer).**

Interceptor and airline

- **Every 3 months**: in installations without milkline or in parlours with milkline and feeding concentrate during milking: clean the airline and the interceptor with a detergent solution **(farmer)**.

Vacuum regulator

- **Once a month**: clean filters and valves; before using, verify that the vacuum level is right **(farmer)**.
- **Once a year**: dismantle every part of the regulator and change worn elements if necessary **(dealer)**.

Pulsation system

- **At each milking**: verify pulse tube and change if cracked or pierced **(farmer)**.
- **Once a month**: clear air inlet and clean (or change) filters; check pulsation rate **(farmer)**.
- **Every 6 months**: total cleaning of the pneumatic pulsators with warm water and detergent, rinse with water and dry **(farmer)**.
- **Once a year**: check electronic pulsators and relays and change worn components if necessary **(dealer)**.

Milk system

Liners

- **at each milking:** check every liners before using in order to avoid twisted and cracked or pierced liners, distorted mouthpiece lips, etc. Have a look at short and long milk tubes and change if necessary **(farmer)**.
- **Once a year (or more if necessary)**: change all rubber liners of the plant **(farmer or dealer)**.
- **Every two years (or more if necessary)**: change all silicone liners of the plant **(farmer or dealer)**.

Claws

- **At each milking:** check air vents and automatic shut-off valves **(farmer)**.

Milkline, receiver, sanitary trap, milk pump

- **At each milking:** check leakages, cleanliness of the sanitary trap and of the receiver (if transparent), connection at the receiver **(farmer)**.
- **Once a month:** check gaskets at the receiver **(farmer)**.
- **Once a year**: check milk pump and non-return valve **(dealer).**

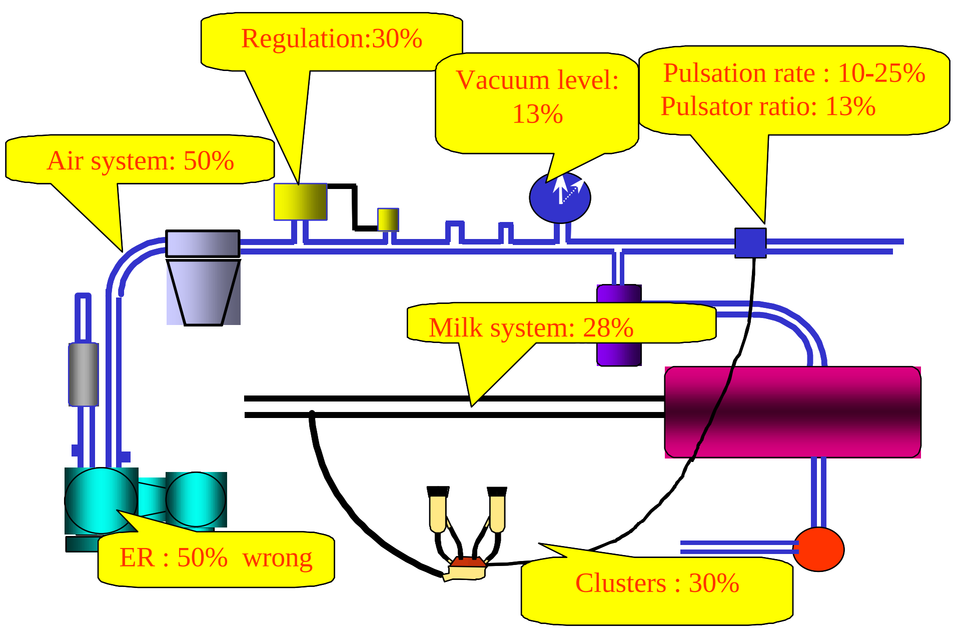
The whole machine: check every year **(dealer)**.

Why Check the Milking Machine?

A study carried out in France in 1700 installations for dairy sheep checked during 3 years (Billon etale, 2003) showed that a lot of defects were found on the different investigated machines.

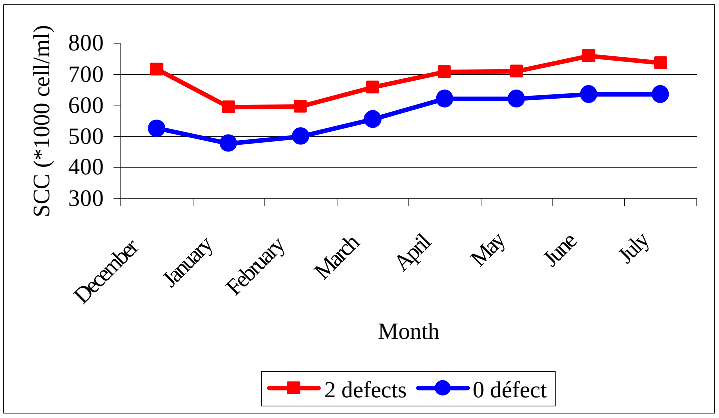
More than 50% of milking installations checked during the study did not completely fulfil the requirements and were not in good order for at least one of the main points described on figure 1. At the end of checking, 70% were improved and fulfilled the requirements only because the technician adjusted and cleaned pulsators and regulators and other main parts of the machine. We have to notice that many tasks could be done by the operator himself.

Figure 1. Percentage of components which did not fulfil requirements



Direct relationships between bad working of some important components of the milking machine and somatic cell counts in the bulk tank are not easy to demonstrate. However, our study showed that milk from flocks with a milking machine with no defects had less SCC than those with a milking machine with 2 defects (figure 2).

Figure 2. Average SCC of bulk tanks during a campaign according to the number of defects in milking machines



Conclusion

The milking machine is a specific tool which must be able to obtain milk of the best quality as possible without stress for animals and/or getting into trouble with udder health.

Even if the different components of a milking machine are calculated in relationship with the characteristics of the animals, such as anatomy of the udder, physiology of milk let down, milking ability of the ewes, etc., they still have to be maintained in good order for use every day and during the whole lactation of the flock. Maintenance and checking of milking equipment must be the main function of farmers.

Another important parameter is the milker. A good machine, perfect in accordance with International Standards and local recommendations, may lead to bad results if the skill of the operator and milking routine are poor.

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THE DESIGNING OF SMALL AND MEDIUM SIZED MILKING MACHINES FOR DAIRY SHEEP

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Abstract

Basically, the ISO standard 5707 (Milking machines installations: construction and performance) applies to milking machines for small ruminants for qualitative and quantitative requirements that are similar for dairy cattle such as vacuum regulation, sizing airlines, vacuum gages and receiver. Specific quantitative requirements for sheep were introduced by a group of experts within the International Dairy Federation (I.D.F.) and published in a bulletin in March 2002.

New recommendations, especially for vacuum pump capacity and effective reserve, are now available. For ewes, they take into account the type of cluster used, the number of operators with the type of machine (bucket or milkline) and the number of units. Vacuum pump capacity is also calculated referring to air used during the cleaning process (only for machine with milkline). Furthermore, regulation must be well adjusted in order to maintain a stable vacuum within the plant at every moment of milking.

Pulsation characteristics are important for ewes because they have a direct influence on stimulation of milk let-down. The best pulsation rate should be 150-180 cycles/min and a pulsator ratio of 50%.

Sizing milklines is similar to cows but taking into account the particular milk kinetics of the East-Friesian ewes and the type of cluster used.

Finally, recent recordings of vacuum beyond the teat and in the claw (or SMT) and of liner movements presented in this document can be useful for helping farmers in their choice of new equipment.

Résumé

La norme de construction et de performances des machines à traire (ISO 5707) s'applique aux petits ruminants, et en particulier aux brebis, uniquement pour les recommandations de type qualitatif. Des recommandations d'ordre quantitatif ont été proposées par un groupe d'experts internationaux au sein de la Fédération Internationale de Laiterie (F.I.L.) et on été publiées dans un bulletin de la FIL en 2002.

Les recommandations spécifiques pour les brebis portent d'abord sur la détermination de la capacité de la pompe à vide et la notion de Réserve Réelle. Pour les brebis, et contrairement aux vaches, elle est fonction, du type de faisceau trayeur utilisé et du nombre de trayeurs, mais aussi du type de machine (pots à terre ou

lactoduc) et du nombre de postes de traite. La capacité de la pompe à vide doit aussi tenir compte des besoins en air pendant la phase de nettoyage (uniquement pour les installations avec lactoduc). De plus, la régulation du vide doit être assurée dans les meilleures conditions afin de permettre un vide le plus stable possible pendant la traite dans toute l'installation.

Les caractéristiques de pulsation chez les brebis sont les suivantes : 150 à 180 cycles/min avec un rapport de 50%. Elles ont une influence directe sur la stimulation de l'éjection du lait.

La détermination du diamètre intérieur du lactoduc est basée sur le même principe que pour les vaches en tenant compte des cinétiques d'émission du lait des brebis et en particulier celle de la race East-Friesian et également du type de faisceau trayeur utilisé.

Enfin, le choix du faisceau trayeur (griffe et manchon trayeur) est abordé à travers des récents enregistrements réalisés en laboratoire tenant en compte l'évolution du niveau de vide sous le trayon et les mouvements du manchon pendant la traite.

Introduction

A milking machine is an assembly of different components which have to work together in the best conditions in order to produce a milk of high quality and to secure udder health of milked animals.

Ewes, like other species such as cows and goats, are milked with a specific machine which applies vacuum (under atmospheric pressure) under the teat in order to open the streak canal through which flows the milk held in the cistern of the gland.

Every component of the milking machine must be figured taking into account different parameters such as: the breed and milk ability of animals, anatomy and physiology of udders, special needs of ewes, skill of operators, etc.

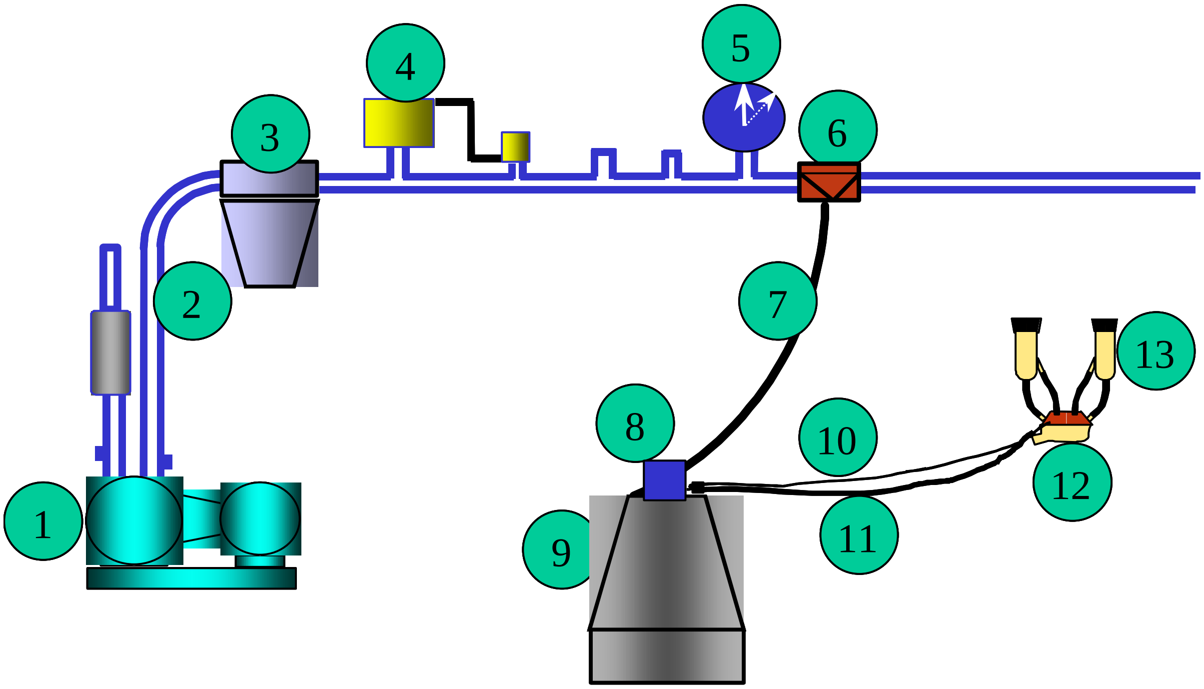
This document attempts to give an overview of the design of a milking machine for ewes. The main parameters such as determination of the vacuum pump capacity with the right effective reserve (ER), sizing milklines and some considerations regarding clusters were discussed in an international group of experts and published in a bulletin of the International Dairy Federation (IDF).

Other results coming from our own researches and field observations are also described and explained because they are useful to have a better understanding of how the milking machine works and its main effects on animals.

The Main Components of a Milking Machine

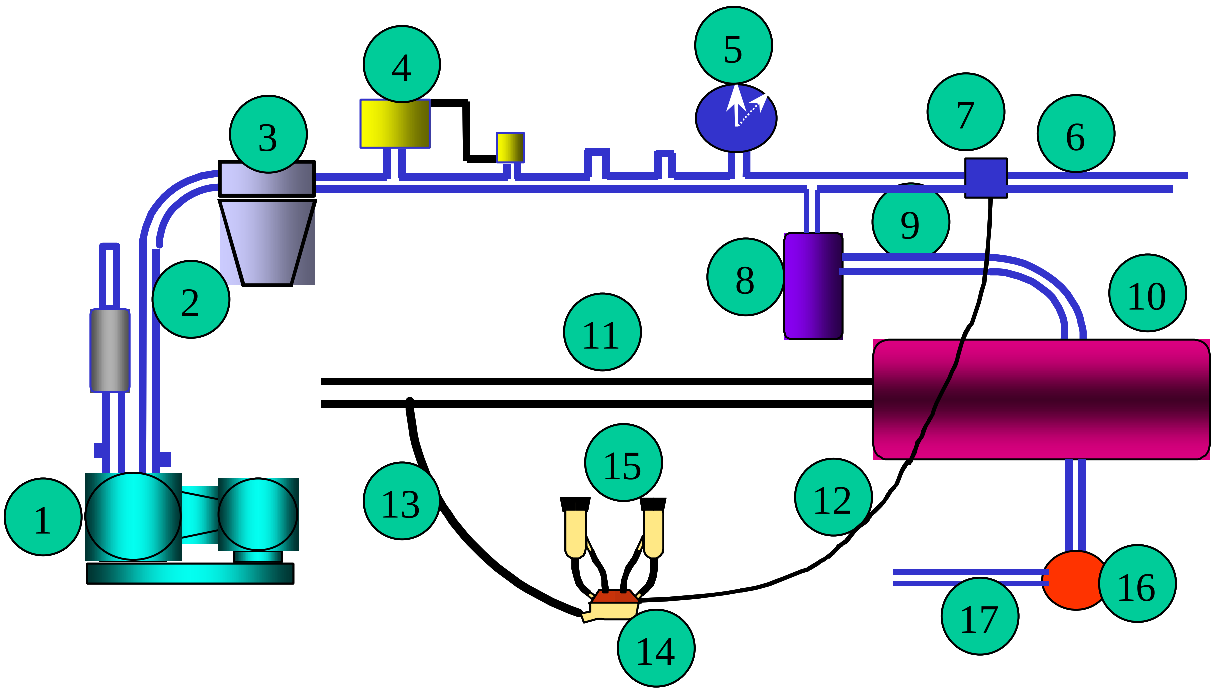
They are described in figure 1 (bucket milking machine) and in figure 2 (milkline milking machine).

Figure 1. Example of a bucket milking machine (from ISO 3918)



1 Vacuum pump	5 Vacuum gauge	8 Pulsator	11 Long milk tube
2 Airline	6 Vacuum tap	9 Bucket	12 Claw
3 Interceptor	7 Vacuum tube	10 Long pulse tube	13 Teatcups
4 Regulator			

Figure 2. Example of a pipeline milking machine (from ISO 3918)



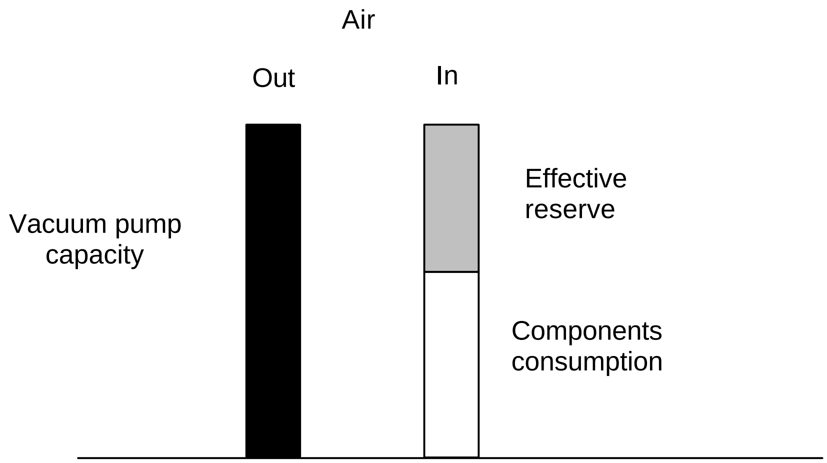
1 Vacuum pump	5 Vacuum gauge	9 Airline receiver	12 Long pulse tube	15 Teatcups
2 Main airline	6 Pulsator airline	10 Receiver	13 Long milk tube	16 Milk pump
3 Interceptor	7 Pulsator	11 Milkline	14 Claw	17 Delivery line
4 Regulator	8 Sanitary trap			

Effective Reserve and Vacuum Pump Capacity

The effective reserve (ER) can be defined as an indication of the reserve airflow capacity actually available to maintain the vacuum within 2 kPa when air is accidentally admitted during milking. It is assumed that a vacuum drop of 2 kPa has little or no effect on milking performance.

It is also the difference between the vacuum pump capacity and the air consumption of the different components of the milking machine as shown in figure 3.

Figure 3. Effective reserve of a milking machine



When ER is too small, vacuum stability within the machine is not maintaine, leading to large vacuum drops which can damage udders and teats. Old Irish studies showed a negative effect on dairy cattle, but there is no reason that this physical phenomena doesn't lead to the same conclusion for ewes.

ER for sheep is figured taking into account the type of cluster used, the number of milkers and milking practices in this species.

Four main types of clusters are marketed:

- conventional clusters (similar to those used for cows) without automatic shut-off device at the claw,
- conventional clusters with automatic shut-off,
- non-conventional cluster with automatic teatcup valves.
- non-conventional cluster with automatic teatcup valves with automatic teatcup removers.

For more than 15 years, manufacturers have been selling special clusters (non-conventional clusters) including a device called "automatic teatcup valve" which opens for vacuum to the liner when the teatcup is attached and automatically shuts off when the teatcup is detached or the unit falls off. This kind of cluster prevents air entering into the milking plant during handling units in order to maintain a good vacuum stability.

We consider that using clusters with automatic teatcup valves provides nearly the same milking conditions as those for cows when the milker works carefully during unit attachment and detachment. Then, effective reserve for dairy sheep should be relatively similar to the effective reserve for cows taking into account that claws and liners are different, the volume beyond the teat is smaller, and the frequency of liner slips and fall-offs is certainly higher. With this kind of cluster, the intake of air is reduced to a minimum but, when idle, they may need extra air for working: 20 up to 50 l/min, depending on the model. This amount of extra air must be stated by the manufacturer.

With conventional clusters (similar to claw used for cows) without automatic shut-off valves in the milking unit as defined in ISO 3918, the risk is very high that milkers do not shut off the vacuum at the liner when they attach and when they detach clusters from udders. In this case, ER should compensate at least for the total air admission of a fully open cluster, which has been evaluated at 600 litres/minute (21.2 cfm). In these conditions, and unlike dairy cows, the air admission during unit attachment depends particularly on the number of milkers because there is risk that different milkers may generate the same fault at the same time.

With conventional clusters with automatic shut-off valves, it is possible for the milker to work more carefully when using this device. Then the air admission during attachment, which also depends on the number of milkers (more risks than for cows especially during attachments), should be similar to transient air entering into an installation for cows used by a normal operator.

The installation shall have a minimum ER determined in accordance with table 1. For each kind of cluster, ER also depends on the type of installation (pipeline or bucket) and of the number of units.

Table 1: Minimum effective reserve for different types of clusters (in litres/minute of free air)

Number of units *n*	Minimum effective reserve [a], in l/min of free air	
	Pipelines	Buckets
Non-conventional cluster with automatic teatcup valve		
$n \leq 10$	200 + 20*n* + *n*E	100 + 20*n* + *n*E
> 10	400 + 10(*n* - 10) + *n*E	300 + 10(*n* - 10) + *n*E
Non-conventional cluster with automatic teatcup valve and automatic teatcup removal		
$n \leq 10$	200 + 20*n*	
> 10	400 + 10(*n* - 10)	
Conventional cluster without automatic shut-off valve		
$n \leq 10$	200 + 20*n* + 400M	100 + 20*n* + 200M
> 10	400 + 10(*n* - 10) + 400M	300 + 10(*n* - 10) + 200M
Conventional cluster with automatic shut-off valve		
$n \leq 10$	200 + 20*n* + 200M	100 + 20*n* + 100M
> 10	400 + 10(*n* - 10) + 200M	300 + 10(*n* - 10) + 100M

[a] Plus additional for ancillary equipment

E= extra air needed for clusters equipped with automatic teacup valves.
M = Number of Milkers; n = number of units

Tables 2 to 5 give some examples of ER for small and medium sized installations according to formulas given in table 1.

Table 2. Minimum effective reserve for milking, in l/min of free air: conventional clusters without automatic shut-off at the claw (in cfm)

No units	Pipeline milking machines		Bucket milking machines	
	1 milker	2 milkers	1 milker	2 milkers
2	640 (22.6)	1040 (36.7)	340 (12.0)	540 (19.1)
3	660 (23.2)	1060 (37.5)	360 (12.7)	560 (19.8)
4	680 (24.0)	1080 (38.2)	380 (13.4)	580 (20.5)
6	720 (25.4)	1120 (39.6)		
8	760 (26.9)	1160 (41.0)		
10	800 (28.3)	1200 (42.4)		
12	820 (29.0)	1220(43.1)		
16	860 (30.4)	1260 (44.5)		

Table 3. Minimum effective reserve for milking, in l/min of free air: conventional clusters with automatic shut-off at the claw (in cfm)

No units	Pipeline milking machines		Bucket milking machines	
	1 milker	2 milkers	1 milker	2 milkers
2	440 (15.5)	640 (22.6)	240 (8.5)	340 (12.0)
3	460 (16.3)	660 (23.3)	260 (9.2)	360 (12.7)
4	480 (17.0)	680 (24.0)	280 (9.9)	380 (13.4)
6	520 (18.4)	720 (25.4)	320 (11.3)	420 (14.8)
8	560 (19.8)	760 (26.9)	360 (12.7)	460 (16.3)
10	600 (21.2)	800 (28.3)	400 (14.1)	500 (17.7)
12	620 (21.9)	820 (29.0)	420 (14.8)	520 (18.4)
16	660 (23.3)	860 (30.4)	460 (16.3)	560 (19.8)

Table 4. Minimum effective reserve for milking, in l/min of free air: non-conventional clusters with automatic teatcup valves (examples with extra air of 20 l/min (0.7 cfm) and 40 l/min (10.4 cfm)) (in cfm)

	Pipeline milking machines		Bucket milking machines	
No units	Extra air 20 l/min	Extra air 40 l/min	Extra air 20 l/min	Extra air 40 l/min
2	280 (9.9)	320 (11.3)	180 (6.4)	220 (7.8)
3	320 (11.3)	380 (13.4)	220 (7.8)	280 (9.9)
4	360 (12.7)	440 (15.5)	260 (9.2)	340 (12.0)
6	440 (15.5)	560 (19.8)		
8	520 (18.4)	680 (24.0)		
10	600 (21.2)	800 (28.3)		
12	660 (23.3)	900 (31.8)		
16	780 (27.6)	1100 (38.9)		

Table 5. Minimum effective reserve for milking, in l/min of free air: non conventional clusters with automatic teatcup valves and automatic cluster removal.

no units	Pipeline milking machines
6	320 (11.3)
12	420 (14.8)
16	460 (16.3)

Influence of altitude

For installations at altitudes of less than or equal to 300 metres, an atmospheric pressure of 100 kPa shall be assumed for calculating effective reserve. To fulfil the requirements at altitudes higher than 300 meters, a vacuum pump with increased capacity shall be installed. Table 6 gives standard atmospheric pressure and correction factors at various altitudes.

Table 6: Standard atmospheric pressure (p_s), and correction factor *H* at various altitudes (example)

Altitude (m)	Atm press.	Correction factor *H* for a vacuum level of the pump of (kPa)												
	(kPa)	30	31	32	33	34	35	36	37	38	39	40	41	42
0- 300	100	.67	.68	.69	.70	.71	.73	.74	.75	.77	.78	.80	.82	.83
300-700	95	.68	.70	.71	.72	.74	.75	.77	.78	.80	.82	.84	.85	.87
700-1200	90	.71	.72	.73	.75	.77	.78	.80	.82	.84	.86	.88	.90	.92
1200-1700	85	.73	.75	.76	.78	.80	.82	.84	.86	.88	.91	.93	.96	.99

For example, if a milking plant for dairy sheep is to be installed at 1000 meters (3280 feet) above the sea level with a vacuum pump working at 40 kPa (12.inches Hg) (1200 /min (42.4 cfm) of capacity at 50 kPa (15 inches Hg) at the sea level), the real capacity of the pump at 1500 meters height and 40 kPa will be 1200/0.88 = 1364 l/min (48.2 cfm).

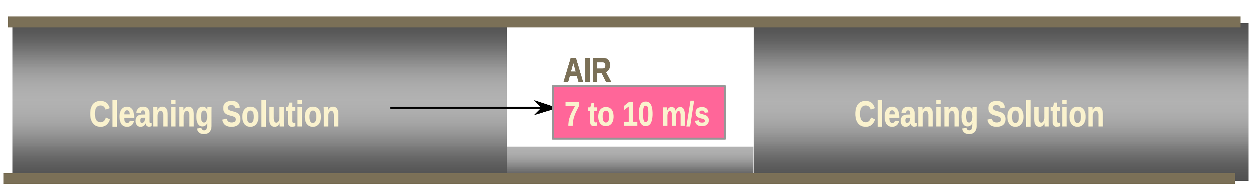
Air used for cleaning

Milklines are usually cleaned by a mixture of air and cleaning solution transported and agitated by the vacuum difference to achieve effective cleaning by slugs with a speed of 7 m/s to 10 m/s.

Where washing systems rely on high pump capacity to achieve the air speed necessary to produce slugs for washing as shown in figure 4, this capacity, Q_{clean}, is dependent on the following parameters:

- internal diameter of the pipe,
- air and slug speed in the milk tube,
- actual atmospheric pressure during the test,
- vacuum level when washing the plant.

Figure 4. Principle of cleaning of a milkline in a milking machine.



Because of the low vacuum milking level, milking installations for small ruminants with milklines can be washed at a higher vacuum level to ensure a better turbulence of the cleaning solution through the installation. For example, it is recommended to install the milking machine with two regulators : one is adjusted to work at 36 kPa (10.8 inches Hg) during milking (working vacuum) and the other is adjusted at a higher vacuum level and works only during cleaning within the range of 45-50 kPa (12.6-15 inches Hg).

The quantity of air required for cleaning shall be estimated by referring to table 7.

Table 7. Air used for cleaning in litres/minute (at a speed of 8 m/s and atmospheric pressure of 100 kPa)

Vacuum level (kPa)	Internal diameter (mm)	38 (1.5'')	40 (1.6'')	48 (1.9'')	50 (2'')	60 (2.4'')	73(2.9'')
36		348	386	556	603	869	1285
38		338	374	539	584	841	1245
40		327	362	521	565	814	1205
42		316	350	504	547	787	1165

For example, air used for cleaning a milking plant equipped with a milkline of 50 mm internal diameter (2'') and working (during cleaning) at 42 kPa (12.6 inches Hg) is 547 l/min (19.3 cfm) at the sea level and 100 kPa atmospheric pressure.

When estimating the vacuum pump capacity of a given plant, the higher value between ER or air used for cleaning will be chosen.

Vacuum pump capacity

The vacuum pump should be capable of withdrawing all air from the milking plant whether it is introduced by different components such as pulsators, regulator, units, or milkers when handling units, and its capacity must be sufficient so that the vacuum drop in the receiver (or close to the receiver) does not exceed 2 kPa during the course of normal milking, including teatcup attachment and removal and liner slips.

The capacity of a vacuum pump is estimated taking into account ER and air demand for cleaning, maximum tolerated consumption of the different components of the milking machine and the eventual correction for altitude.

First example: estimation of a vacuum pump capacity for a bucket milking machine installed at 200 meters above the sea level:

a) machine with 2 double buckets with 4 conventional units without automatic shut-off at the claw,
b) one milker,
c) working vacuum level: 36 kPa (10.8 inches Hg),
d) air admission in the clusters: 8 l/min (0.3 cfm),
e) number of pneumatic pulsators: 2,
f) air consumption for each pulsators: 35 l/min (1.6 cfm),
g) buckets and units hand cleaned.

1 - According to table 1, the effective reserve capacity for milking will be:
100 l/min +(20 x 4) l/min + 200 l/min = 380 l/min (13.4 cfm)
2 – Because of hand cleaning, no special air used for cleaning is required,

3 - Air consumption for the milking units (air admission and pulsators will be: (8x 4) l/min + (35 x 2) l/min = 102 l/min (3.6 cfm).
4 - Total air demand during milking will be: 380 l/min + 102 l/min = 482 l/min (17.0 cfm).
5 - Regulation loss is 10 % of the manual reserve. The effective reserve was 380 l/min and is smaller than the manual reserve.

Consequently:
Manual reserve = 380 l/min x 100/(100-10) = 422 l/min (14.9 cfm)
regulation loss 422 l/min x 10/100 = 42 l/min (1.5 cfm)
total: 482 l/min + 42 l/min = 524 l/min (18.5 cfm)
10 - Leakage into the airlines are equal to 5 % of the pump capacity, that is
vacuum system leakage: 524 l/min x 5/100-5) = 27 l/min (0.9 cfm)
total: 524 l/min + 27 l/min = 551 l/min (19.5 cfm)
11 - With a pressure drop of 3 kPa between pump and measuring point the vacuum level at the pump will be: 36 kPa + 3 kPa = 39 kPa (11.7 inches Hg)
551 l/min (19.5 cfm) is the pump capacity at its working vacuum level (39 kPa or 11.7 inches Hg))

Table 6 gives a correction factor of 0.78 for a vacuum of 39 kPa for an atmospheric pressure of 100 kPa and a vacuum level of 50 kPa at 200 meters high:

The nominal pump capacity will be: 551 l/min x 0.78 = 430 l/min (15.2 cfm).

Second example: milking parlour with 12 units, automatic teatcup valves, valve located at 1000 m above the sea level:

a) one milker,
b) working vacuum level: 38 kPa (11.4 inches Hg),
c) milkline internal diameter: 48 mm (1.9''),
d) air admission in the clusters: 8 l/min (0.3 cfm),
e) extra air needed at clusters: 20 l/min (0.7 cfm),
f) number of pulsators: 6,
g) air consumption for each pulsators: 25 l/min (0.9 cfm),
h) vacuum level for cleaning: 50 kPa (15 inches Hg)

1 - According to table 1 the effective reserve capacity for milking will be:
400 l/min +(10 x 2) l/min + (12 x 20) l/min = 660 l/min (23.3 cfm)

2 - According to table 7 the air demand for cleaning at 50 kPa for a milkline of 48 mm internal diameter and at an altitude of 1000 m should be 386 l/min (13.6 cfm) which is lower than the effective reserve for milking

3 - Air consumption for the milking units (air admission and pulsators will be: (8x 12) l/min + (25 x 6) l/min = 246 l/min (8.7 cfm)

4 - Total air demand during milking will be: 660 l/min + 246 l/min = 906 l/min (32.0 cfm)

5 - Total air demand during cleaning will be: 434 l/min + 246 l/min = 680 l/min (24.0 cfm)

6 - In this example the capacity for milking is larger and therefore shall be taken as a basis for the pump dimensioning.

7 - Leakage into the milk system: 10 l/min + (2 x 12) l/min = 34 l/min (1.2 cfm)

8 - Total: 906 l/min + 34 l/min = 940 l/min (33.2 cfm)

9 - Regulation loss is 10 % of the manual reserve. The effective reserve was 660 l/min (23.3 cfm) and is smaller than the manual reserve. Consequently:

Manual reserve = 660 l/min x 100/(100-10) = 733 l/min (25.9 cfm)
regulation loss 733 l/min ; x 10/100 = 73 l/min (2.6 cfm)
total: 940 l/min + 73 l/min = 1013 l/min (35.8 cfm).

10 - Leakage into the airlines are equal to 5 % of the pump capacity, that is vacuum system leakage: 1013 l/min x 5/100-5) = 53 l/min (1.9 cfm)

total: 1013 l/min + 53 l/min = 1066 l/min (37.7 cfm)

11 - With a pressure drop of 3 kPa between pump and measuring point the vacuum level at the pump will be: 38 kPa + 3 kPa = 41 kPa (12.3 inches Hg).

<u>1066 l/min (37.7 cfm) is the vacuum pump capacity at its working vacuum,</u>

Correction for the higher altitude in accordance with table 6 for the altitude of 1000 m and a vacuum of 41 kPa will give a correction factor of 0.90 for an atmospheric pressure of 100 kPa and a vacuum level of 50 kPa.

<u>The nominal pump capacity is: 1066 l/min x 0.9 = 959l/min (33.9 cfm)</u>

Regulation

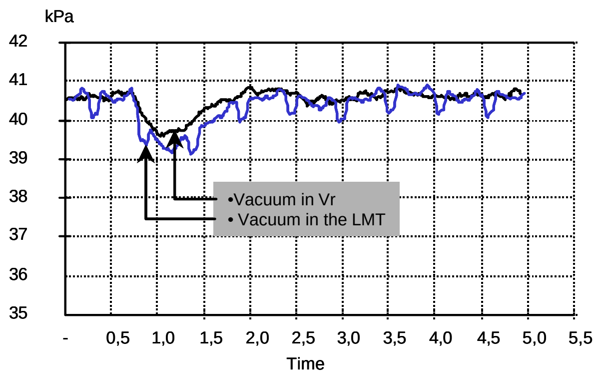
The regulator is one of the main parts of a milking machine. Its role is to keep the vacuum level constant within the range of 2 kPa during the course of normal milking, including teatcup attachment and removal, liner slips or teatcups falls-off for at least 99% of the milking time.

Self controlled regulators are good devices and easily fulfil the requirements. They only have to be maintained in good order by good maintenance.

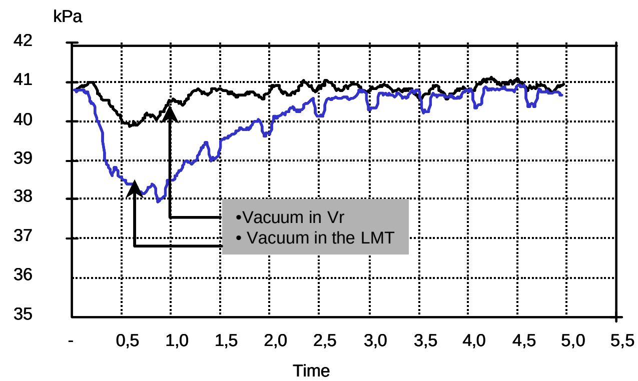
A regulator has to be sensitive (<1 kPa). Sensitivity of the regulator is the difference of working vacuum when the machine is working with no milking unit connected, and all units connected. A lower sensitivity can lead to a higher and/or unstable working vacuum which has bad effects on udder health and teat end conditions.

A high regulation loss (air flow through the regulator when it normally would be closed) indicates some problems of connection or leakages between the regulator and the receiver. This issue leads to higher irregular fluctuations in the long milk tube as shown on figure 5.

Figure 5. Irregular vacuum fluctuations in the Long Milk Tube (LMT) and near the regulator (Vr) with (a) and without (b) regulation loss when a large amount of air suddenly enters into the installation



(a)



(b)

Irregular fluctuations simultaneously occur under the teat. When associated with large cyclic variations which can be generated by some clusters and/ or in certain conditions, it is a real source of udder infections as it has been shown for dairy cattle for more than 35 years. (Nyhan, 1968; Thiel et al, 1973; Bramley, 1991). In addition, large irregular fluctuations may decrease vacuum under the teat which can lead to liner slips and impacts of infected droplets of milk on the teat end; providing another source of infection. (Thiel et al. 1969; Le Du, 1977; Thompson et Pearson, 1979; O'Shea et al, 1984 ; Bramley, 1991).

Too much regulator leakage means that the regulator is open when it should be closed. That leads to an unstable vacuum and milking troubles as described above. This is often due to bad maintenance of the regulator.

Vacuum level of a given installation has to be adjusted taking into account different parameters such as:

- milking ability of ewes
- type of liner and cluster
- skill of the operator(s)
- type of milking machine (bucket, low or high milkline).

Too high vacuum can lead to poor teat end conditions and udder infections, more stripping but faster milking. Too low of vacuum results in a milking duration increase, and more liner slips and fall-offs can be observed. Then, it is easy to understand that the best vacuum for a given installation is a compromise between all these parameters.

Usually, the following vacuum levels are advised:

34-38 kPa (10.2-11.4 inches Hg) for buckets and low milklines
38-40 kPa (11.4-12 inches Hg) for high line milklines.

Pulsation System

Type of pulsators

2 types of pulsators are used : pneumatic and electronic.

Pneumatic pulsators are traditionally used in very small plants with buckets, for example. They are very simple devices only working with vacuum. However, their characteristics, especially pulsation rate, are vacuum sensitive. For example if the regulator fails or if the farmer wants to change the working vacuum, pulsation rate will also change. Pulsator ratio is also affected but in a smaller proportion.

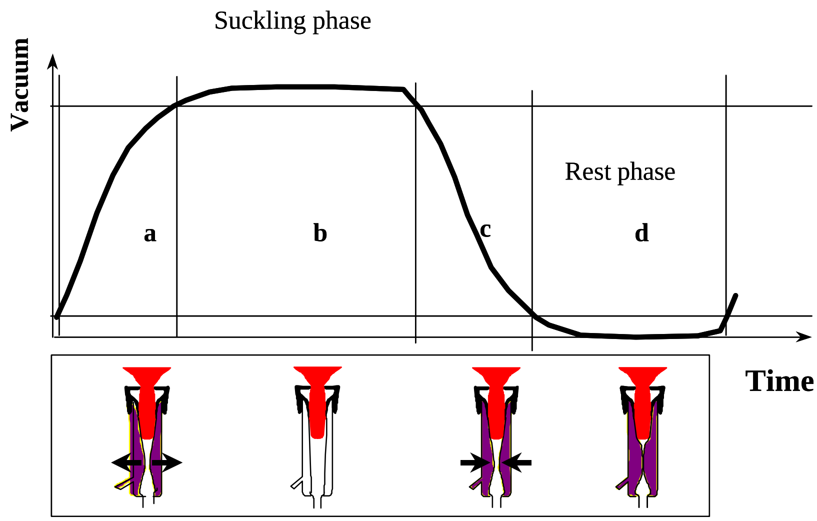
The main drawback of pneumatic pulsators is a tendency for failure due to worn pieces and moisture. A French study (Sauvée et al, 1998) showed that less than three months after having being checked and adjusted, more than half of them were still out of order. That means that pneumatic pulsators have to be checked very often (every month for example) and maintained in a good order by at least cleaning filters and changing worn components. The risk of failure increases when feeding ewes during milking due to dust generated by concentrate foodstuffs falling down into mangers. In this case, cleaning and maintenance have to be reinforced.

Electronic pulsators are now used in milking parlours. They have two main components: a pulsation generator which is an electric and electronic device that sends electric signals to an electric relay or a pulsator. Generally, in dairy sheep milking machines, one relay or pulsator is used for two units. Electronic pulsators are more reliable because pulsation rate doesn’t change with vacuum and is stable. Obviously, pulsator ratio can also fail if relays are not clean enough. However, the above mentioned French study showed that most electronic pulsators were still working well 18 months after their last adjustment. Unfortunately, they are more expensive, but they lead to more relaxed milking conditions both for milkers and animals.

So, it is recommended to use electronic pulsation instead of a pneumatic one, especially in milking parlours.

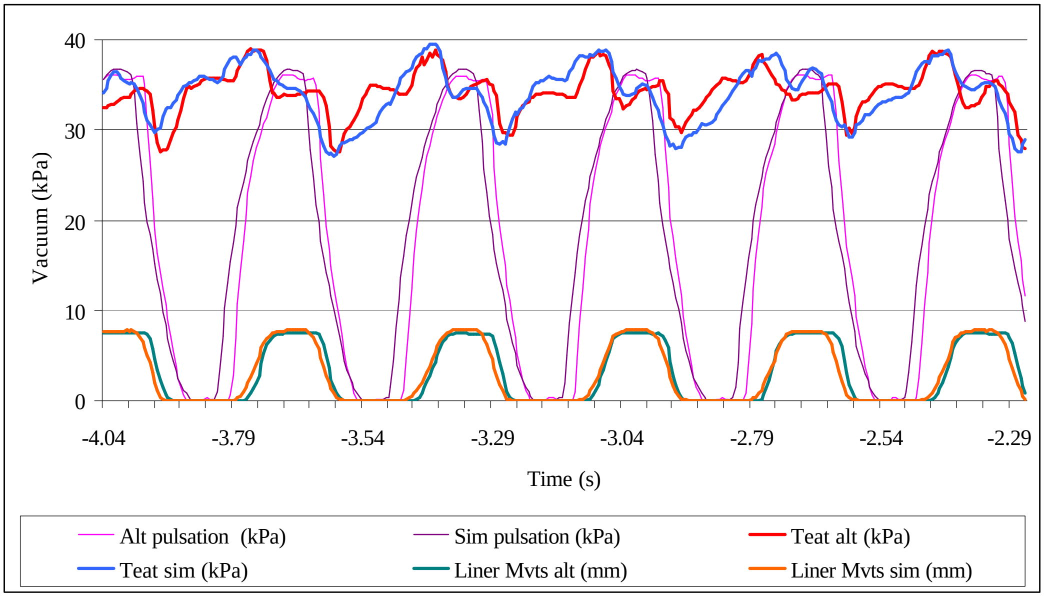
In dairy sheep milking machines, pulsators used are simultaneous pulsators. That means that each half udder is at the same time in the suckling phase and in the rest phase (figure 6).

Figure 6. Different phases of the pulsation curve



Recent researches (Billon et al., 2004) showed that there are no technical reasons for using alternate pulsation for dairy ewes with modern clusters and liners (similar average, minimum and maximum teat end vacuum and similar movement of the liner) (figure 7). The only reason for choosing alternate pulsation in dairy sheep milking machines should be when using very small clusters with small internal diameter of the short milk tubes in order to avoid claw flooding by dividing the milk flow rate by 2.

Figure 7. Vacuum under the teat and in the claw, and movements of the liner at simultaneous and alternative pulsation in a modern cluster in low line. (1.5 l/min liquid flow rate at 36 kPa (10.8 inches Hg).



In milking parlours, it is recommended that filtered atmospheric air be used for the pulsators in order to maintain clean relays for the longest time as possible. The air filter should be installed in a place where it cannot be contaminated with dust coming from forage or other goods that can taint dairy products.

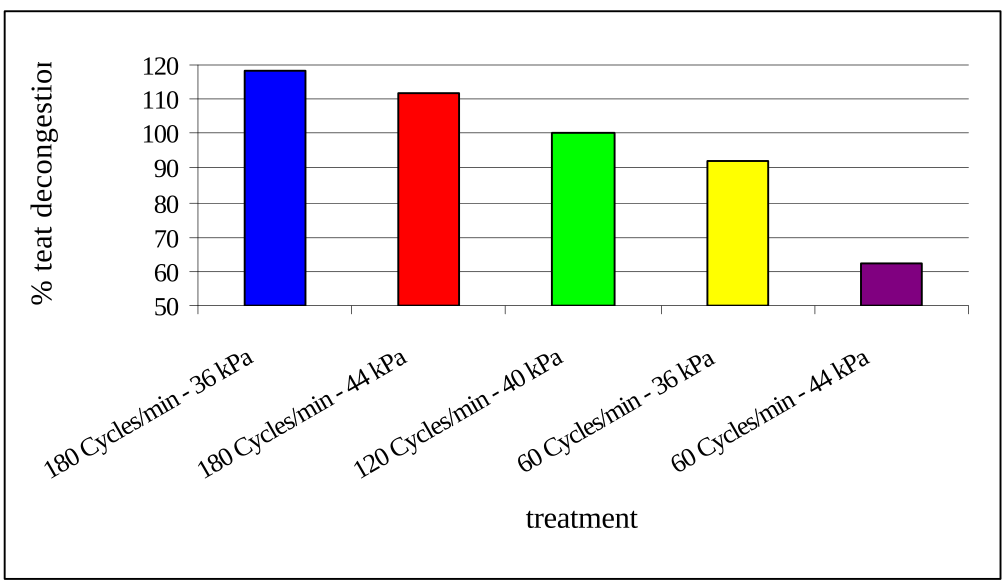
Pulsation rate

A survey carried out by the International Dairy federation (I.D.F.) in 1998 showed that pulsation rate for dairy sheep is usually in the range from 90 to 180 cycles/min. A lot of studies showed that a high pulsation rate is necessary to obtain the most milk during the shortest milking time. For example, Le Du (1981) showed that a pulsation rate of 180 cycles/min leads to a shorter machine on time, more fat content, similar machine yield and more total milk due to more stripping milk and obviously greater stripping time. However, this study was carried out at a 44 kPa vacuum level in high line parlour; it is likely the main cause of a higher level of stripping.

French field experiences confirm everyday that a high pulsation rate leads to better milking conditions and not necessarily to a higher amount of stripping milk which depends both on the shape of the udder and on the teats location on the udder.

In addition, a fast pulsation rate leads to better teat end conditions (Marnet et al., 2002) (figure 8).

Figure 8. Relationship between teat end conditions and pulsation rate and working vacuum level



More recent field observations in France on different breeds showed that pulsation rate should not be less than 150 cycles per minute. 180 cycles/min should be the pulsation rate for high yielding ewes such as the Lacaune breed.

When checking, the pulsation rate must not deviate by more than 5 % from the values given by the installer. It is easy to check the pulsation rate with the thumb into the mouthpiece chamber during half a minute or one minute. If the number of massages during one minute shows a higher deviation than 5% from the initial value, the pulsators must, at least, be cleaned. If no amelioration occurs after cleaning, the pulsators must be checked by the dealer.

<u>Pulsator ratio</u>

Traditionally, pulsator ratio used in milking machines for sheep is 50%. A pulsator ratio of 60% is possible. In certain cases a higher ratio improves the pulsation curve and movements of the liner, especially when the liner is open leading to a quicker milking.

When checking, the pulsator ratio must not differ more than ± 5 units of percentage from the values given by the installer. In addition, pulsator ratios of all pulsators of an installation must not vary from each other by more than 5 units of percentage, and, in case of alternate pulsation, the two teatcups may not vary from each other by more than 5 %.

Because it is more difficult to check the ratio without special tools and recording devices, it is recommended that the dealer check every pulsator at least once a year and more often for pneumatic devices.

<u>Pulsation phases</u>

Right now, there is no evidence, and no scientific proof, of effects of pulsation phases on milking and udder health for dairy sheep. More research is needed.

Milk System

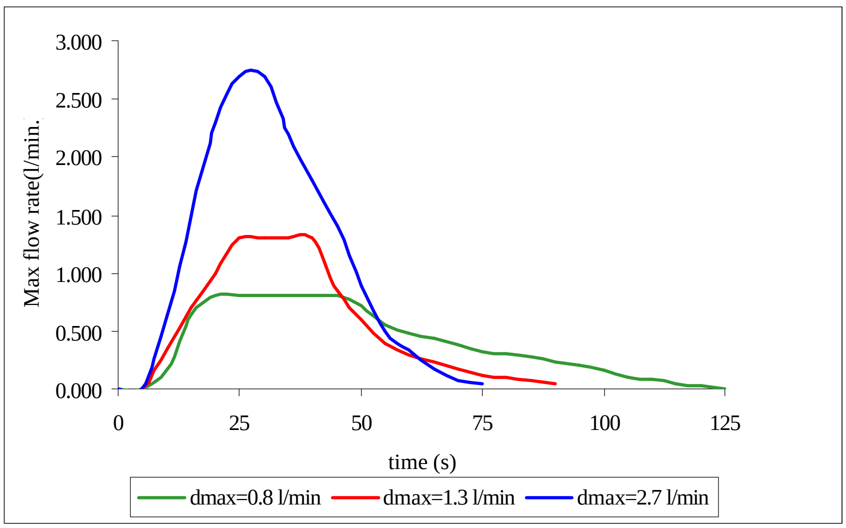
<u>Minimum internal diameter of milklines</u>

Ideally in a milkline, milk should flow in the lower part of the pipeline with a clear continuous space above for the much larger volume of air to pass over it. This flow condition is known as stratified flow. In practice, flow typically varies between stratified flow and slug flow. Slug flow occurs whenever slugs of milk fill the entire cross-section of the milkline. Slug flow conditions in the milkline almost always induce transient vacuum drops greater than 2 kPa. Chronic slugging in the milkline is likely to have almost the same effect on milking performance and milk quality as raising the milkline height by about 300 mm to 500 mm, i.e., slower milking and more liner slips (because of lower minimum liner vacuum), and higher acid degree values. Milkline vacuum almost always remains stable within ± 2 kPa of the receiver vacuum under stratified flow conditions. Therefore, the limit of 2 kPa essentially means that stratified flow should be the normal flow condition in the milkline.

Experimental laboratory studies have been carried out to determine the maximum milk flow rate to ensure that stratified flow is the normal flow condition during dairy cattle milking. There is apparently no reason why equations figured for cattle should not apply to small ruminants if the ratio between steady air flow and milk flow is chosen according to real milking conditions of these species. For example, with dairy cattle, the experimental data were based on a ratio of 10 l/min (0.35 cfm) steady air flow at the unit per 4.5 l/min liquid per unit, i.e. a ratio of 2.2.

However, the problem is more difficult with small ruminants because maximum flow rate can vary between between breeds. Thus, it is suggested that equations referring to dairy cattle (ISO 5707) for three different ratios based on 8 l/min (0.28 cfm) steady air per unit (refer to the paragraph related to air vent and leakage at the unit) and three milk flow rates apply: 0.8 l/min for species and breeds with low maximum milk flow rates (Lacaune and Manech breeds for example), 1.3 l/min for species and breeds with medium maximum milk flow rates (Manchega, Churra and Laxta breeds for example), and 2.7 l/min for species and breeds with high maximum milk flow rates (Sardinian breed for example). Referring to the results of McKusick et al. (2002), a milk ejection curve for East Friesian ewes in Wisconsin is similar to the one for medium maximum milk flow rate such as Manchega, Chura or Laxta breeds (average parameters: maximum flow rate - 1.24 l/min, milk flow latency - 13.1 seconds, machine milking time - 105.9 seconds) (figure 9).

Figure 9. Typical milk flow rate curves for sheep



Maximum milk flow in the milkline can be predicted from the milk flow curves taking into account the breed and the average attachment rate. Then it is possible to figure the maximum milk flow per slope to ensure that stratified flow is the normal condition during milking. The calculated milk flow must be less (or at least equal) to the predicted milk flow in the milkline.

Tables 8 shows examples of the predicted maximum milk flow rate of a group of sheep with maximum milk flow rates of 0.8 and 1.3 l/min and for units attached at intervals of 5 and 10 seconds which are common milking routines for small ruminants.

Table 8: Maximum predicted milk flow rate in litres/minute in milklines for sheep

No units	6	10	12	16
Attch[t] rate (s)	Maximum flow rate : 0.8 l/min			
5	4.8	7.3	8.2	9.0
10	4.1	4.6	4.6	4.6
	Maximum flow rate : 1.3 l/min			
5	7.1	9.1	9.6	10.0
10	4.9	5.2	5.2	5.2

The main parameters for sizing milklines are the following:

- type of cluster and transient air when handling for each kind of cluster,
- slope of the milkline,
- configuration of the milkline (looped or dead-ended),
- attachment rate,
- maximum predicted milk flow rate.

The designed air flow conditions are based on a steady air admission of 8 l/min (0.3 cfm) through air vents and constant leaks at the cluster, plus intermittent air flows associated with attachment, liner slips and removal.

The proposed guidelines for transient air must be consistent with the other requirements and particularly with the ER calculation and are the following:

1- for conventional clusters without automatic shut-off valve: 400 l/min (14.1 cfm) for intermittent air flow into a dead-ended line, or 200 l/min (7.1 cfm) per slope for a looped milk line

2- for conventional clusters with automatic shut-off valve: 200 l/min (7.1 cfm) for intermittent air flow into a dead-ended line, or 100 l/min (3.5 cfm) per slope for a looped milk line

3- for non-conventional clusters (with automatic teatcup valves): 50 l/min (1.8 cfm) for intermittent air flow into a dead-ended line, or 25 l/min (0.9 cfm) per slope for a looped milk line

A special Excel sheet was made in order to facilitate calculations. See example in figure 10.

Figure 10. Milklines sizing

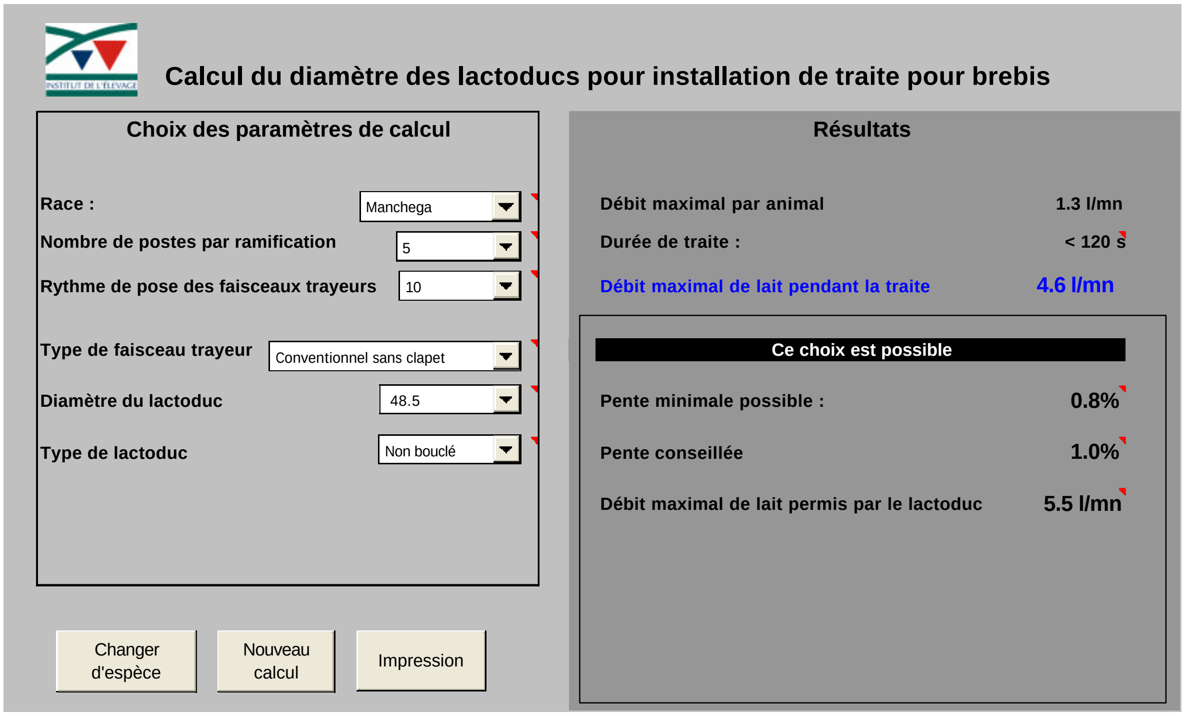


Table 9 gives an example of the maximal number of units per slope for East Friesian ewes (dmax = 1.3 l/min) and a milkline of 48.5 mm (2'') internal diameter at an attachment rate of 5 s.

Table 9: Maximal number of units per slope for ewes with dmax = 1.3 l/min and a milkline of 48.5 mm (2'') internal diameter and an interval attachment of 5 s.

Type of Cluster	Looped milklines (dead-ended milklines) slope (%)			
	0.5	1.0	1.5	2.0
Conventional without automatic shut-off	3 (2)	9 (3)	* (7)	* (*)
Conventional with automatic shut-off	5 (3)	* (9)	* (*)	* (*)
Non conventional with automatic teatcups valves	4 (*)	9 (*)	* (*)	* (*)

* = unlimited number of milking units

For other calculations (i.e. different attachment rates, other diameters,…), use the Excel sheet.

Cluster Assembly

Long milk tube

The long milk tube can have a large effect on vacuum fluctuations under the teat. To minimize this issue, its internal diameter must be greater than 12.5 mm (or at least equal). When using a high level milkline, and because of the column of milk to be lifted from the claw to the milkline, the internal diameter of the long milk tube shall be less than 14.5 mm (or at least equal).

When using low level milkline, length of the long milk tube must be as short as possible without a bend in order to avoid milk being lifted into the milkline.

Short milk tube

To reduce the likelihood of milk plugs in the short milk tube and reverse flow and/or impacts against the teat, it is recommended to use a short milk tube with internal diameter of at least 9 mm.

Claw

Clusters used in milking machines for sheep have a claw of 50-100 cc, but some of them are only made with tubes of stainless steel, or plastic, as a Y shape. This kind of claw can milk ewes while maintaining desired vacuum only if the internal diameter of the short milk tubes (SMT) is at least 9 mm and if the air vent is in good order. Then the bowl is not necessary.

Conventional clusters can be equipped with an automatic shut-off device at the claw. With such a device, it is easier for the operator to limit air entering into the installation during detachments and when going from one animal to another. It also shuts off the vacuum when the cluster falls off onto the platform. Obviously, it leads to less air into the plant and less bacteria in the milk. At least, an easy-to-use clamp should be installed on the long milk tube.

Air vent and leakage

An air vent at the cluster is necessary in order to avoid flooded claws and/or slugs in short milk tubes. With clusters including a liner with an elbow and a long short milk tube (25 up to 30 cm -10 to 12 inches-), it is recommended to locate the air vent at each teatcup just above or at the elbow leads for a better milking, better draining of tubes and claws (Le Du, 1981) (table 10) and less vacuum fluctuations under teats.

Air vent	Total Milk	Stripping milk	Machine Milking time	Average flow rate
At the claw	756	94.5	91	436.1
At the claw AND at the bend	771	84.1	85.1	484.3
Stat	NS	**	*	*

Table 10. Influence of the place of air vent on milking

The total air intake per cluster from the air vent and air leakage (conventional clusters) must not exceed 8 l/min (0.28 cfm) and must allow at least 4 l/min of free air (0.14 cfm) at the nominal working vacuum level. That means that a constant effort of the operator has to be done in order to maintain the air vent free of dust and moisture.

In conventional clusters, a maximum of 2 l/min at the shut-off device is tolerated.

<u>Liner</u>

The liner is one of the most important components of a milking machine, yet this is relatively unknown. The main characteristics of a liner should be the following:

- quick and gently milking of every animals,
- limiting stripping,
- limiting liner slips and avoiding fall-off,
- limited influence on somatic cells count (SCC) and clinical mastitis,
- limited influence on free fatty acids (FFA).

Le Du (1981) showed that liners made of silicone produced the same amount of stripping milk compared with liners made with rubber. Another study by the same author compared 4 liners, the characteristics of which are shown in table 11. This study was performed on Lacaune ewes with a lowline milking machine working at 36 kPa (10.8 inches Hg), a pulsation rate of 172 cycles/min, and a pulsator ratio of 50%.

Table 11. Characteristics of studied liners

Liner / Parameter	Ref	A	B	C
Mouthpiece lip ID (mm)	20	22	15	20
Barrel ID (mm) (top)	19	19	20	21
Barrel ID (mm) (bottom)	19	19	16	21
Buckling pressure (kPa)	10.7	10	10	4.7

Results show that for Lacaune ewes, and likely for ewes with similar milking ability and udder and teats morphology, a good liner has a mouthpiece lip diameter not greater than 19 mm, a tapered and smooth barrel (table 12). The lowest amount of milk during stripping was obtained with two different liners, one with a tapered barrel and the other with a larger bore. That is consistent with other studies carried out on cows. Machine-on time was the lowest when the liner bore was not too high (around 19 mm) or tapered. Liner B gave the best compromise between all requirements and objectives mentioned earlier. In addition, the better teat end conditions after the 48 days of experimentation lead to the conclusion that a soft liner with a low buckling pressure (7-8 kPa) is likely interesting. However, too low buckling pressure as liner C in the experiment seems to indicate too weak of material because early distorted mouthpiece lips were observed.

Table12. Milking characteristics of different studied liners (Lacaune breed)

Liner	Total milk yield (ml)	Stripping yield (ml)	Stripping yield (%)	Machine milking time (s)	Average milk flow rate (l/min)	Number of fall-off (%)	Number of slipping (%)
Ref	1708	232	13.8	246	386		
Ref	1720	236	13.8	251	377		
Ref	1749	224	12.8	244	400	0.69 [b]	2.31 [a]
A	1625	282 [a]	17.7	260 [a]	338 [a]	4.86 [c]	2.99 [b]
B	1622	209 [b]	13.2	242 [b]	378 [b]	0.35 [a]	2.50 [a]
C	1643	203 [b]	12.5	254 [b]	368 [b]	1.18 [b]	2.01 [a]
Stat	NS	P<0.001	NS	P<0.001	P<0.001	P<0.001	P<0.001

[a,b,c] : values with the same letter in the same column do not differ statistically.

To conclude, a good liner should have the following characteristics :

- made in silicone and soft,
- with a narrow mouthpiece lip (not greater than 19 mm)
- with a narrow bore or tapered barrel,
- with an air vent at the bend of the short milk tube,
- and not too expansive!!.

The choice of a cluster

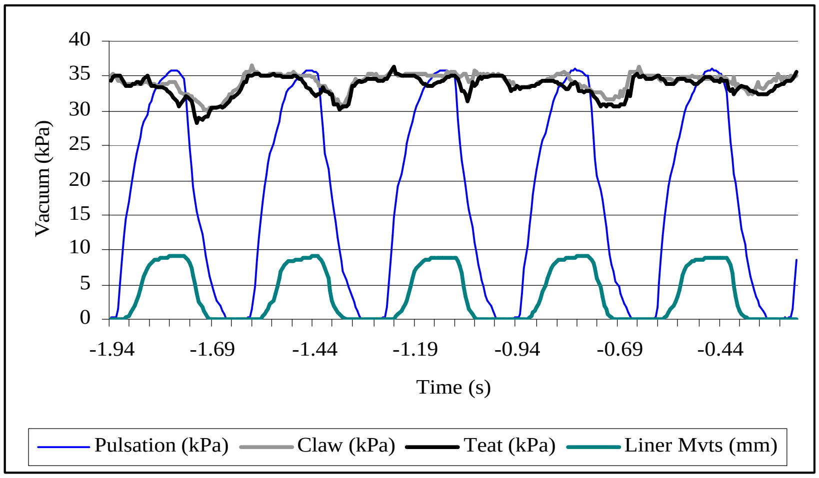
It is always very difficult to choose the right cluster able to milk rapidly and gently the total number of ewes in a given flock with only a few risks to udder health and with good utilization of labour. Quick and gentle milking will be especially managed by choosing the right vacuum level and the better pulsation characteristics (see previous paragraph).

Following are the main properties of a good cluster:

- good handling in order to guarantee good working conditions but also to limit air admission into the installation during attachments and detachments. Clusters with automatic teatcups valves are surely the best solution but conventional clusters can be appropriate if operators work carefully. In this case, an automatic shut-off device will be a good assistant. These solutions limit impacts of milk droplets against teat ends which are well known to be a major factor of introduction of pathogens into the streak canal during milking.

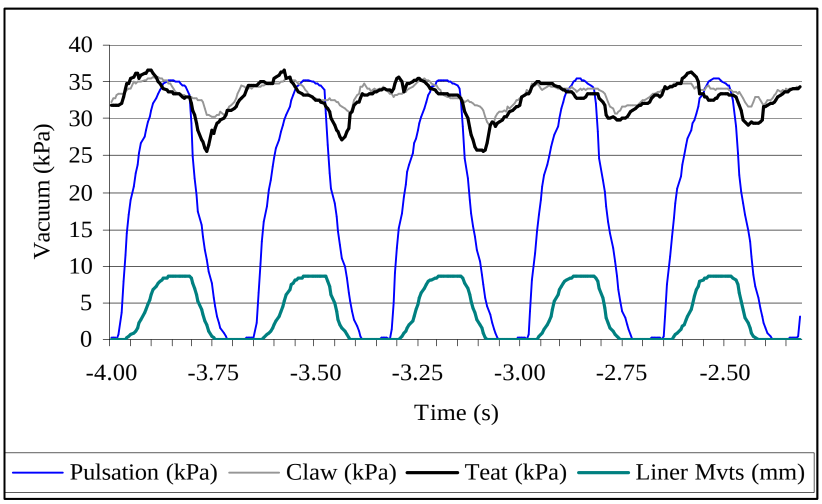
- Good vacuum stability under the teat during milking. That means that vacuum drops due to milk flow through the cluster must be as low as possible and both vacuum under the teat and vacuum at the milk outlet of the claw have to be the most similar as possible as shown on figure 11.

Figure 11. Vacuum and liner movements in a typical good cluster (LL, 36 kPa and 1.5 l/min milk flow rate)



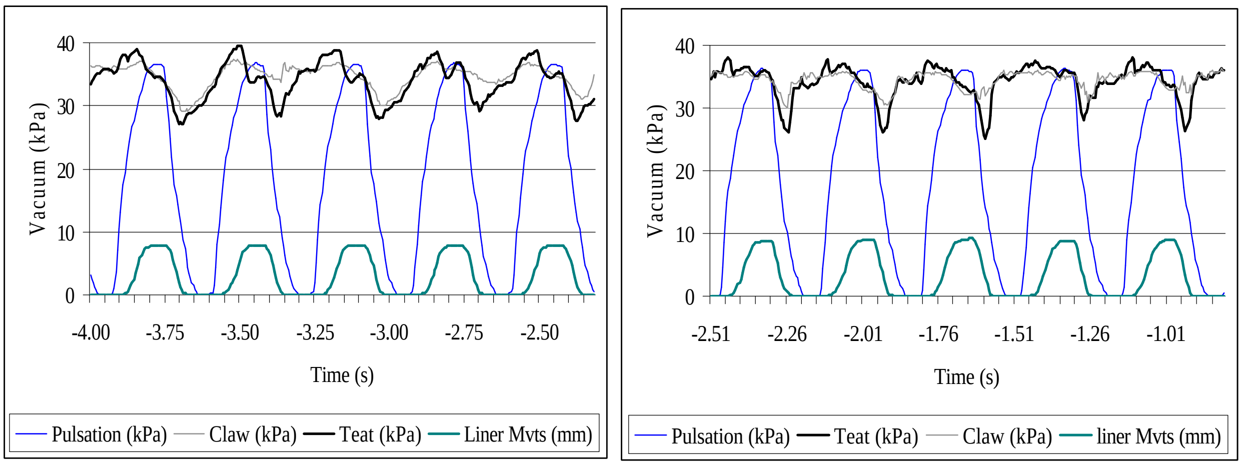
In some cases, the minimum vacuum under the teat can dramatically decrease principally due to a too small of diameter of the short milk tube (figure 12). In extreme situations this phenomena can lead to liner slips and fall-off which are a source of unstable vacuum and of impacts.

Figure 12. Vacuum and liner movements in a cluster with a small ID of the SMT (LL, 36 kPa and 1.5 l/min milk flow rate



When the cluster is not appropriate and especially when the free volume under the teat is too small due, for example, to flooding, minimum vacuum under the teat decreases as mentioned just above. In addition, maximum vacuum, which occurs when the liner is opening raises to a higher level then the nominal vacuum and a higher level than the vacuum within the claw at the same time. Then, milk which was flowing from the teat (top) to the claw (bottom) is re-suckled from the claw (or the SMT) to the teat. That is what specialists call “reverse flow”. Teats are washed by milk and bacteria living on udder’s skin can be deposit all around the extremity of the steak canal, ready to be introduced during milking or at the end of milking just before the canal is completely closed (figure 13).

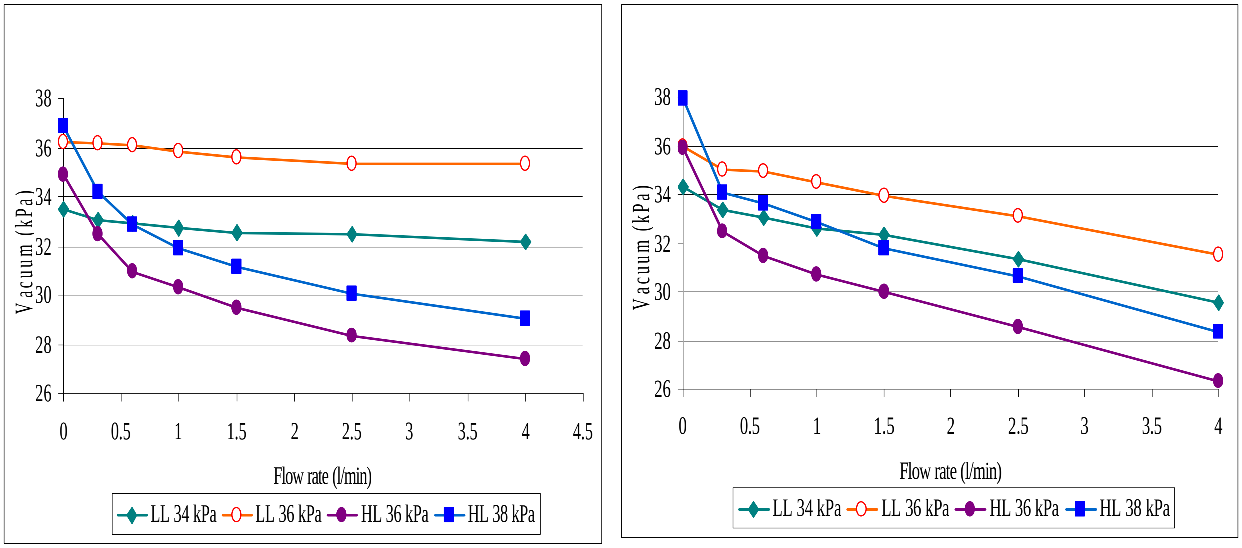
Figure 13. Vacuum and liner movements in two clusters with a flooded claw or SMT (LL, 36 kPa and 1.5 l/min milk flow rate)



- In addition with dimensional aspects mentioned in the previous paragraph, movements of the liner are very important. Despite the high pulsation rate, we can observe a real ‘suckling’ phase when the liner is completely open and a real ‘rest’ phase with the liner is collapsed (see figures 11 to 13). Obviously, duration of these phases vary from liner to liner. Laboratory recordings with 8 different kinds of clusters, now used for sheep worldwide, showed that the duration of the ‘suckling’ phase varied from 62 up to 111 ms, and the duration of the ‘rest’ phase varied between 73 and 167 ms. That shows that for several liners the ‘rest’ phase is longer that the ‘suckling’ phase. More research is needed in order to define what should be the best duration.

- Finally, recent studies show that some clusters are less dependent than others on milk flow. Figures 14 show two examples of evolution of the average vacuum under the teat of two clusters in high and low milklines. When the average vacuum under the teat is practically constant, that means that every ewe can be milked at the same vacuum level at each moment of milking. Obviously, more research is also needed in order to ensure that constant vacuum conditions during milking of ewes are absolutely necessary.

Figure 14. Average vacuum under the teat in relationship with milk flow rate and the type of milkline



Conclusion

A milking machine must be properly sized, taking into account both animals and operator(s). Each component of the machine is important, and all of them must perfectly work together in order to avoid milk quality issues and udder health troubles. The milker must not believe that the biggest is the best: for example, bigger vacuum pump or larger milkline internal diameter than needed are obviously more expensive when buying but also when working: higher energy, water and hygiene products consumption.

In addition, a bad operator will automatically lead to bad milking and bad results. Efforts should be done by farmers in milking routine so that they try to limit overmilking, for example and for maintenance of the main components such as the vacuum pump, the regulator and pulsators.

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MILK TESTING, CALCULATION OF MILK PRODUCTION, AND ADJUSTMENT FACTORS

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(Most of the following article has already been published in different proceedings or newsletters (J-DSANA) but the authors consider the subject to be important enough to be worth repeating and published under one article for easy access by the public.)

Summary

The improvement of milk production through selection is practically impossible without knowing the milk production of each individual. Even in small flocks, in which the shepherd has an intimate knowledge of his animals, the estimation of milk production is often inaccurate. When the time comes to choose replacement ewe lambs, to cull poor performing ewes, or to keep or sell young dairy ram lambs, the producer needs to rely on accurate information. The only way to have a good estimation of milk production is to record the milk production of the ewes at certain days throughout the milking period and to use the numbers recorded to calculate the total production. This production will have to be adjusted for age of the ewes, lamb management system used and length of lactation in order to compare different animals. The whole system requires a commitment from the producer as well as some financial investment either to acquire the necessary equipment or to use the services of professional organisms such as DHIA.

Equipment Needed

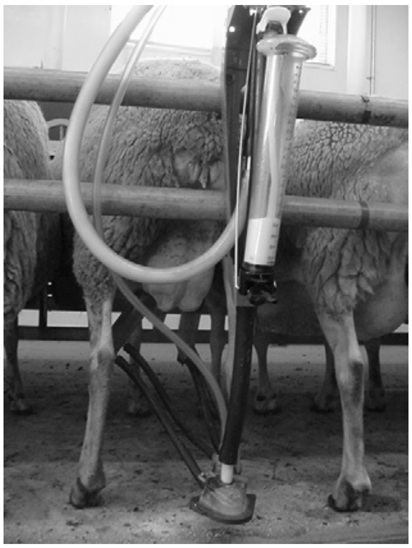
The recording of milk production can be done either by weight or by volume. Therefore, in small operations not willing to invest an important sum of money, the use of a scale (electronic or mechanical) can be envisaged. The milking bucket can be set on top of the scale and a new reading recorded for each ewe. This system is slow, not very accurate, and does not offer the possibility of collecting milk samples. For more accuracy, an investment in regular meter jars is necessary. There are two basic types of meter jars: permanent jars that are an integral part of the milking system (picture 1), and removable jars that are set up in the milking system only on testing days as shown in pictures 2 and 3. The principal features to look for in a meter jar are:

- Easy to read. The milk entering the jar has a tendency to foam and too much foam makes an accurate reading difficult. Many jars are designed to limit the amount of foam.
- Accurate and consistent.
- Should not create fluctuation in the vacuum level of the whole milking system.

- Possibility of taking milk samples. This is an important feature for the control of milk quality and its inclusion in a selection program.
- Easy to empty between each animal.
- Easy to clean, either manually or with a Cleaning in Place system.

Picture 1. Permanently installed meter jars in a low line pipeline.

Picture 2. Meter jars installed in a low line pipeline on testing day



Picture 3. Meter jar installed in a high line pipeline on testing day

Identification of Animals

The control of production cannot be done without some sort of animal identification. The simplest identification is the common ear tag. However, since milking of the ewes is done from the rear, and the person doing the milking is always at a lower level than the ewes (either standing in a pit, or the ewes standing on a platform), the reading of ear tags is difficult without stepping up in front of the ewes. To help in the identification, a number could be put on the animal either on the rump with livestock paint or on a plastic band placed on the rear leg.

The use of electronic identification either through electronic ear tags, implanted transponders or transponders in rumen boluses can greatly facilitate testing and reduce errors. The reading of the electronic devices can easily be done from the rear as shown in the following pictures using a reader.


Pictures 3 and 4. Reading of electronic rumen boluses and electronic ear tags.

How and When to Do Testing

Because the same language needs to be used by everyone in order to have reliable comparison of animals, the International Committee for Animal Recording published, in 1992, the guidelines for milk recording of sheep.

The first test day of the flock takes place 4 to 15 days after the start of milking for that year or season. Subsequent test days should take place at 28 to 34 day intervals until all ewes are dried off. Three basic choices are given for milk recording:

1. **Method A4**. This is the method of reference. On each test day, milk yield is recorded at both milkings (a.m. and p.m.) and added together to determine daily yield. This method is the most time consuming. Milk samples are generally taken at the morning milking.

2. **Method AC**. Individual milk yield is recorded at one milking only (either a.m. or p.m.), and total flock yield is determined by the quantity of milk in the tank after the 2 milkings. The total amount of milk in the tank is divided by the sum of the

individual yields of either morning or evening. The resulting factor is used to determine the individual daily milk yield for the day of the control. For example if the total amount in the tank after the morning and evening milkings is 350 lbs and the sum of all ewes at one milking is 200, the multiplying factor is 350/200 = 1.75. The daily production of a ewe recorded at 1.2 liters at one test is 1.2 x 1.75 = 2.1 liters. This procedure eliminates the need to individually record ewes twice at each test day. Expenses and time are therefore reduced. However, the milk in the tank must come only from ewes that were tested.

3. **Method AT**. This method is also called alternative method. Tests are performed at one milking only. On a test day ewes are recorded on the a.m. milking only, and at the next test day ewes are recorded on the p.m. milking only. At each test, the recorded figure is multiplied by 2 in order to obtain the total daily milk yield. The method is simple and accurate if the condition that milk yield recorded at alerternate a.m. and p.m. milkings is respected. This method avoids cumbersome calculations.

Any method is acceptable but cannot be changed in the middle of lactation. The producer has to decide before the milking season starts which method should be used.

Milk samples should be taken from each ewe and analyzed for fat and protein content, and for somatic cell count (SCC) at least three times during the milking period.

Milk yield can be recorded by weight or volume, although volume is preferred. Since the rest of the sheep dairy world uses metric measurements, it would be desirable to use the weight measures of grams or kilograms or the volume measures of milliliters or liters. The volume to weight conversion for normal sheep milk is: 1 liter = 1.036 kilograms, or 1 liter = 2.28 pounds, or 1 gallon (U.S.) = 8.64 pounds.

Calculation of Total Milk Yield

Individual milk production for the **milking period only** can be estimated using the centering date method as in the following formula:

Estimated milk yield =
[production 1st test day x no. days between start of milking and 1st test day]
+ [(prod. 1st test day + prod. 2nd test day)/2 x no. days between 1st and 2nd test day]
+ [(prod. 2nd test day + prod. 3rd test day)/2 x no. days between 2nd and 3rd test day]
+.....
+ [(prod. next to last test day + prod. last test day)/2 x no. days between next to last and last test day]
+ [prod. last test day x no. days between last test day and end of milking]

The formula assumes that milk production changes in a linear fashion between milk recording days, that is, that milk production goes up or down by the same amount each day of the period. Although the assumption of a linear change is not quite true, it is however, a close approximation of reality.

It is important to make the distinction between lactation length and milking period. Lactation length refers to the suckling period plus the milking period. Unless the suckling period is zero (ewe milked shortly after lambing), the estimation of milk yield is for the milking period only.

Estimation of Average Fat and Protein Percentage

Because milk yield and the fat and protein percentage of milk changes during lactation, it is not possible to simply make an average of all fat and protein percentages obtained at each test day. The fat and protein percentage measurements need to be weighted by the amount of milk that was produced at the time the sample was taken to get the fat or protein yield. The fat or protein yield related to the total milk yield will give the average fat or protein percentage during the milking period. The formula to be used is similar to the one used for milk yield.

Estimated fat (or protein) yield =
[((production 1st test day x %fat 1st test day)/100) x no. days between start of milking and 1st test day]
+ [((((prod. 1st test day x %fat 1rst test day)/100) + ((prod. 2nd test day x %fat 2nd test day)/100))/2) x no. days between 1st and 2nd test day]
+ [((((prod. 2nd test day x %fat 2nd test day)/100) + ((prod. 3rd test day x %fat 3rd test day)100))/2) x no. days between 2nd and 3rd test day]
+.....
+ [((((prod. next to last test day x %fat next to last test day)/100) + ((prod. last test day x %fat last test day)/100))/2) x no. days between next to last and last test day]
+ [((prod. last test day x %fat last test day)/100) x no. days between last test day and end of milking]

$$\textbf{Average fat (or protein) percentage} = \frac{\text{Estimated fat (or protein) yield}}{\text{Estimated milk yield}} \times 100$$

Adjustment Factors

The estimated milk yield and the average fat and protein percentage are not sufficient by themselves to compare all animals in the flock and make a selection. The total milk production of a ewe depends on her age, the type of lamb management (ewe raising her lambs or ewe put at milking directly after lambing) and the length of lactation or milking period. Therefore, the estimated total milk production needs to be adjusted for those different non-genetic factors. For example, after adjustment, the production record of a first lactation ewe milking for 120 days after having raised her lambs for 30 days can be compared to a 4 year old ewe milking for 180 days right after lambing.

Adjustment for lactation length

Lactation length is a desirable trait because, in general, the longer the lactation the more milk a ewe will produce. However, in a flock, all ewes are not given the opportunity to lactate for the same number of days because they did not lamb at the same time (sometimes one or two months apart) and because the producer decides to stop milking all ewes at the same time. Therefore the potential production of the ewes may be either overestimated or underestimated if yields are not adjusted for different lactation lengths.

Thomas (2003) suggests that the U.S. dairy sheep industry selects a standard lactation length of 180 days. It is important to understand the following:

- The 180-day period starts on lambing day. The milk produced during the suckling period **is neither estimated nor included.** Only the milk produced during the milking period is included.
- If milking starts shortly after lambing (DY1 management), there is no suckling period.
- If a MIX management is used (milking once a day while ewes are raising their lambs) only the quantity of milk obtained at milking is included.
- Ewes that dry-off prior to 180 days post-lambing should not be credited for any milk from the day of dry-off until 180 days post lambing.
- For ewes that lactate longer than 180 days, the quantity of milk produced after 180 days post lambing is **neither estimated nor included**.

For ewes that lactate longer than 180 days the milk production can be estimated using the same basic formula slightly modified to reflect the 180-day limitation:

180-day estimated milk yield =
[production 1st test day x no. days between start of milking and 1st test day]
+ [(prod. 1st test day + prod. 2nd test day)/2 x no. days between 1st and 2nd test day]
+ [(prod. 2nd test day + prod. 3rd test day)/2 x no. days between 2nd and 3rd test day]
+.....
+ [(prod. next to last test day prior to 180 days post lambing + prod. last test day prior to 180 days post lambing)/2 x no. days between next to last prior to 180 days post lambing and last test day prior to 180 days post lambing]
+ [prod. last test day prior to 180 days post lambing x no. days between last test day and 180 days post lambing].

Adjustment for lamb management system

There are 3 basic lamb management systems:

- The DY30 system in which the ewes raise their lambs for 30 days after which the lambs are weaned and the ewes milked twice a day
- The MIX system in which the ewes raise their lambs for 30 days but are milked once a day after overnight separation of the lambs. After 30 days, the lambs are weaned, and the ewes milked twice a day.

- The DY1 system in which the lambs are removed from their mother soon after birth, and the ewes are put at milking twice a day.

According to the system used, the amount of milk recorded and estimated will be greatly different. In the DY1 system all the milk produced is included in the calculation of the total production, whereas in the DY30 system the first month of lactation is not included in the calculation of production. In this system, the DY30 ewes are clearly at a disadvantage when compared to DY1 ewes. If more than 1 system are used in the same flock an adjustment of production is necessary. The following multiplicative factors proposed by Thomas (2003) have been directly developed from results at the Spooner Agricultural Research Station, University of Wisconsin-Madison.

Table 1. Multiplicative Factors for Lamb Management Systems

	Lamb Management System		
Yield of:	DY1	MIX	DY30
Milk	1.00	1.10	1.51
Fat	1.00	1.21	1.57
Protein	1.00	1.13	1.50

Adjustment for age

Age of ewe has an important effect on total milk production as well as on fat and protein content. Milk production in average tends to increase from 1st to 4th lactation at which point it reaches a plateau and starts declining after the 8th lactation. The adjustment factors proposed in the following tables are based on European data and might not be as accurate as they should be for the breeds used in North America. However, it is preferable to use these factors than none at all. North American data should be available in the future.

Table 2. Multiplicative Factors for Age of Ewe

Ewe age, years	Adjustment factors
1	1.44
2	1.24
3	1.13
4 to 7	1.00
8 and older	1.04

Example: A 2 year-old ewe has a milk production of 206 liters. Her age-adjusted milk yield is 255 liters (206 x 1.24 = 255 liters).

The following 2 tables give 2 examples of how to calculate the 180-day lactation production and how to apply the different adjustment factors. After adjustment, comparisons can be made on the production (in bold).

Age of ewe	2		
Lamb management	MIX		
Date of lambing	2/25		
Weaning date	3/25		
Date Start milking	2/27		
Date of 180-day lactation	8/24		
Test date	Daily milk (kg)	# days x average of 2 tests	Total milk for period
3/1	1.5	3 x 1.5	4.5
3/15	2	15 x (1.5 + 2)/2	26.3
4/1	2.5	16 x (2 + 2.5)/2	36
5/1	2	30 x (2.5 + 2)/2	67.5
6/1	2	31 x (2 + 2)/2	62
7/1	1.5	30 x (2 + 1.5)/2	52.5
8/1	.7	31 x (1.5 + .7)/2	34.1
8/24 is 180-day lactation		24 x (.7 + .4)/2	13.2
9/1	.4		
Total 180-day production			296.1
Adjustment for age	1.24	296.1 x 1.24	367.2
Adjustment for management	1.10	376.2 x 1.10	**403.9**

Age of ewe	3		
Lamb management	DY30		
Date of lambing	1/25		
Weaning date	2/25		
Date Start milking	2/26		
Date of 180-day lactation	7/24		
Test date	Daily milk (kg)	# days x average of 2 tests	Total milk for period
3/1	2.5	3 x 2.5	7.5
3/15	2	15 x (2.5 + 2)/2	33.8
4/1	1.6	16 x (2 + 1.6)/2	28.8
5/1	1.3	30 x (1.6 + 1.3)/2	43.5
6/1	1.05	31 x (1.3 + 1.05)/2	36.4
7/1	.85	30 x (1.05 + .85)/2	28.5
7/24 is 180-day lactation		24 x (.85 + .7)/2	18.6
8/1	.7		
9/1	.3		
Total 180-day production			197.1
Adjustment for age	1.13	197.1 x 1.13	222.7
Adjustment for management	1.51	222.7 x 1.51	**336.3**

References

International Committee for Animal Recording. 1992. International Regulations for Milk Recording in Sheep. ICAR, Via Alessandro torlonia 15A, I-00161 Roma, Italy.

Thomas, D.L. Calculation of yield of milk, fat and protein in dairy sheep. Journal Dairy Sheep Assoc. of North America. Vol. 2. No. 1. Fall 2003.

FARMING AND THE INCOME TAX SYSTEM
IS IT A BUSINESS OR A HOBBY?

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Summary

Which came first, the farm, the sheep or the dream? Do you have a business background or a long history of farming? Is this your first job or second or third one? What are your long range plans and goals? Do you have a business plan? Do you have short term and five and ten year projections? Are you doing this because you love it or are good at it? Did you know the majority of businesses fail in the first couple years? And this failure is not because the talent or skill is not there, but the paperwork and government regulations bury the small business owner.

Farming is a business and as such needs to be conducted in a businesslike manner. The basics for record-keeping and income tax requirements are similar and the words “farm’ and “business” are interchangeable.

The filing and record-keeping requirements are also similar for Canada and the United States. The majority of the information pertains to both countries. The differences will be noted and referenced to the appropriate publication. The information will pertain to your sheep dairy milking operation and/or your manufacturing and sale of dairy products.

Business vs. Hobby

Your business needs to be a profit-making venture, not a tax shelter. Your business profits are taxable - like the profits of any legitimate enterprise. Your business may even show a tax loss in its early years, which is deductible against other sources of income (e.g., salary), as long as you run the business as a legitimate business engaged in for profit. Whether a profit motive exists rests on all the facts and circumstances - including the nine factors listed in the Internal Revenue Service, IRS, regulations. These factors are:

1. Whether you carry on your activity in a businesslike manner.
2. Whether you, or your advisers, have the knowledge needed to carry on the activity as a successful business.
3. Whether the time and effort you spend on the activity indicates that you intend to make it profitable.
4. Whether you can expect to make a future profit from the appreciation of the assets used in the activity.
5. Whether you have been successful in making a profit in similar activities in the past.

6. Whether the activity makes a profit in some years, and how much profit it makes.
7. The amount of profits earned when compared to losses in other years and profit potential.
8. Whether you depend on income from the activity for your livelihood.
9. The presence of personal elements or recreation.

Under the Canadian tax law, Canada Customs and Revenue Agency, CCRA, farm losses are deductible wholly, partial or not at all depending on the amount of off-farm income.

The IRS requires income from a hobby to be claimed on a Schedule (Sch) F for a farm or a Sch C for a business, subject to self-employment tax, (Sch SE). However, the expenses for a hobby are limited to the income and deductible on the Sch A for itemized deductions.

Organization of Record Keeping

If you are generating gross income, it is your job and your responsibility to keep complete and accurate records of all transactions. Both governments require reporting of all income, including barter income. Record keeping is essential for documentation for government review if necessary, and to provide complete and accurate preparation of your income tax returns.

Keeping track of income and expenses serves another important purpose. Monthly bookkeeping provides information as to what percent are expenses vs. income, what expenses are high or low this month and where is the cash flow. Yearly reports allow for comparisons, provide information to help determine projections, can be used to focus on specific areas and can be analyzed for improvements and changes. Generating or updating a business plan is simpler from accurate data and records.

Organization of records is the key to reducing the fear factor associated with the income tax form. In its simplest version, all income in and all expenses out related to the business operation are to be kept. But what is pertinent and how do you manage the paperwork complicates the task. Having an area designated to put the receipts is a start. Whether it is a basket or box, collecting the slips of paper by emptying the pants pockets, cleaning out the automobile or sorting the mail is crucial. The story of the farmer bringing in his papers in a shoebox or paper bag is a far better situation, than little or no documentation at all. Today's technology offers many alternatives to paper and pencil. Investing in software specific to your operation is only a good value if utilized. A fancy accounting program with all the bells and whistles may actually prove more daunting than a basic checkbook program. The main advantage of a computer program is the ability to add automatically and the ease of year-to-year comparison.

A thirteen-column spreadsheet pad is inexpensive and practical and only needs a calculator to make the job easier. Files and folders and filing cabinets work, but the IRS recommends an alphabetical organizer, cost of just ten dollars, for most small businesses.

The IRS requires a mileage log for an audit. Using a calendar and at a minimum, recording the odometer reading when filling up with gas or at oil changes, along with dates and locations traveled to and purpose, allows construction of a detailed journal. If your primary occupation is farming and you have a vehicle, such as a pick-up truck used mostly for farming, you are allowed to use 75 percent without documentation. However, if used more than 75%, keep a log and benefit from the tax code. A business other than farming, calculates the percent of business use by logging the personal use against total miles driven in the tax year.

An operation is considered a farm if it fits one of the farm codes. This is true for both Canadian and American businesses. (See Handout 1). The tax forms actually list the type of products that qualify the operation to be treated as a farm. This is important as the categories differ from the business form, Sch C, and there are differences in tax treatment. Specifically, the farmland and fuel tax credits, the class life and depreciation schedule of capital purchases and farm income averaging. There are also two different CCRA farm returns, depending if you want to participate in the CAIS program, (Canadian Agricultural Income Stabilization Program).

Sales of hay, grain, milk and defined livestock are farm activities. Production of cheese, yogurt and bottled milk are not farm activities. They are manufacturing and are considered differently from a farm, as a Sch C, business activity. This is true for both countries. But again, be it a farming operation or production, these are businesses and the income and expense requirements apply as well as the Hobby Loss rules.

Income and Expense Categories

A breakdown of the categories most pertinent to sheep dairy are as follows: (Handout 2)

Farm Income: Cash Method	A.	Sale of livestock and other items bought for resale. Cost or basis of livestock and other items sold (above).
	B.	Sale of livestock and product raised: Milk, Feeder Lambs, Market Lambs, Raised Breeding Stock, Crops.
	C.	Other Income: 1099's, 1099 PATR - dividends and cooperative distributions, Agricultural Program Payments, Crop Insurance proceeds, Custom machine work hire, Farmland credits, Fuel tax credit and Farm interest income.
		Include barter income in gross income.

Farm Expenses: Cash & Accrual (Numbering is in accordance with Schedule F – Profit or Loss from Farming)	12.	Car & Truck Expenses: Total Mileage Jan 1 and December 31. Date started odometer reading, business miles Vehicle year/make Gas, repairs, insurance, oil Separate mileage logs for each vehicle used.* Other Auto: Car washes, loan interest, lease payment.* *A percent of business versus total miles driven per year. The percent may vary year-to-year depending on business use.
	13.	Chemicals: Mostly pertains to crops.
	15.	Custom Hire: Machine work, contract to cut hay.
	17.	Employee Benefit Programs other than pension & profit sharing: Includes health insurance and medical expense if qualified under Section 105 Plan. Talk to your tax professional.
	18.	Feed Purchases: Feed mills, hay, barter.
	19.	Fertilizer and Lime: same as Chemicals, mostly refers to crops.
	20.	Freight & Trucking: Hauling fees for livestock or milk, etc.
	21.	Gasoline, Fuel and Oil: For tractors and on-farm equipment use. Different from car and truck expense. Also record gallons of gasoline used off-road for IRS Form 4136.
	22.	Insurance: Liability, Building, Workman's Compensation - not auto or health, see above.
	23.	Interest: A. Farm Business Loan, Mortgage paid to bank. B. Other - Farm Loans, Credit card related to business.
	24.	Labor Hired: Employees and/or spouse. Commodity Wages. Your own children under age 18 may qualify. Talk to your tax professional.
	26.	Rent or Lease: Vehicles, machinery and equipment. Other (land, animals, buildings).
	27.	Repairs & Maintenance: Office equipment and computer repair. Garbage fees. Machinery and Building Repair and Maintenance.
	28.	Seeds and Plants purchased: Write off the year of purchase or capitalized.
	30.	Supplies Purchased: Items for use in business - twine, cleaners, small tools, etc.
	31.	Taxes: Land and building for farm use may be pro-rated, employment taxes - Social security, Medicare.
	32.	Utilities: If separate building - electricity, heat. Percent for barn if shared meters.
	33.	Veterinary, breeding and medicine - Separate these items if purchased with supplies, etc.

	34.	Other: A. Fees: Bank Charges, Renewals. B. Education and Seminars: Meetings, Conventions, etc. C. Marketing and Dues: Can include advertising or list it as a separate expense. D. Meals & Entertainment: 1. Record in a diary, journal or log. Receipts are not needed for meals less than $75 for business reasons. Record dates, where, who with, amounts paid and what discussed. Can be with spouse, significant other, and business acquaintances. Do not count meals by yourself if not qualified overnight stays. 2. Per Diem: Count number of days away for overnight stays. Include the day you left, days away and day returned using 1/4, ½, 3/4 or full day. $36 per person/per day. If meals for that day are greater than $36, use option number one. 3. Entertainment: Movies, events for business. These should be journal entries also. Record total amounts spent for entertainment. The above expenses are allowed at 50% on the tax return. 4. Travel: Motel, airlines, taxi, rental car E. Office Expense: Long distance phone expense, second line, business cards, paper, office supplies, cell phone, percentage used for business, internet access. F. Office in your home: An area used exclusively for business, Does not have to be a separate room, but a separate area. Square feet of “office” Square feet of living space of home Utilities: water/sewer, electricity, heat Homeowners Insurance Property taxes Mortgage Interest, Rent Repairs to office or house Value of house, value of land Large home improvements

The farm or business may be eligible to deduct expenses related to a home office. Form 8829 addresses the expenses allowed and to what extent. Form 8829 can be used as a worksheet for a farm operation. The Canadian counterpart is T1175 for home office expenses. (Handout 3)

Farm Categories that are self-explanatory or where more in-depth knowledge is needed:

*Conservation Expenses
*Depreciation
*Pension and Profit Sharing Plans
*Storage and Warehousing
*Capital Gains, Stepped-up-basis
*Prepaid Expenses (farm only)
*Income Averaging
*Net Operating Loss

Keep in mind expenses need to be "ordinary" and "necessary" to be deductible.

Manufacturing a product and sales of that product are considered a Sch C business and the rules for farming do not apply. The income and expense categories are similar. (Handout 4) Labor hired is called wages. Inventory is considered and cost of goods sold is calculated. Milking and sale of that product and sale of a finished product require different tax treatment and thus two different tax schedules and two separate sets of books for each "business'.

The IRS uses depreciation and depreciation schedules. The Canadian Custom and Revenue Agency calls it CCA, capital cost allocation. Publication RC4060, CCRA, provides an understandable chart of current or capital expenses. (Handout 5)

Many times a business is started and existing equipment and buildings are used. Items used personally and now converted to business use are legitimate business expenses. A listing of each item and the value needs to be established. The CCRA tax laws provide a formula based on Fair Market Value, FMV. However, capital items converted are treated differently than new purchases in regards to depreciation.

The IRS revenue ruling, Section 179, allows for accelerated depreciation of certain capital purchases. In addition, special allowances were created to stimulate the economy and provide tax relief after 9/11. These may be excellent tools for the current tax year and for planning. However, the states have not embraced all aspects of the federal law. This applies in certain areas in regard to the provinces having different requirements than the CCRA as well. Consult a tax professional or revenue publications.

Entity Consideration

Entity consideration becomes more critical with today's litigation prone society. An individual operating his or her business is considered a sole proprietor and files a Sch C or F.

A limited liability company, LLC, as a single member, can elect Corporation status and file an 1120 or for a Sub-S corporation, 1120S, or file a Sch C or F. Husband and wife businesses or more than one individual, also have choices of entities. Again, they can register with their state as a LLC or as a partnership. These entities will file, depending on status election, a 1065, partnership return or the 1120, C corporation or 1120 S, S Corporation return. Liability insurance is probably more of a factor in protecting the business, than the choice of entity. Consulting a tax professional or tax attorney is important in deciding what is best for your specific situation.

If you and your spouse jointly own and operate a business and share in the profits and losses, you are partners in a partnership, whether or not you have a formal partnership agreement. You are not eligible to file Sch C or C-EZ or Sch F. Instead, file Form 1065. See Pub. 541 for more details. The exception being, if you and your spouse wholly own an unincorporated business as community property under the community property laws of a state, foreign country or U.S. possession, you may treat the business either as a sole proprietorship or a partnership. The only states with community property laws are Arizona, California, Idaho, Louisiana, Nevada, New Mexico, Texas, Washington and Wisconsin. A change in your reporting position will be treated as a conversion of the entity.

An important consideration in starting your business, is what, are the federal, state or province and local regulations and requirements? Are you zoned properly, do you need any permits or licenses? A vendor may require a Federal Identification Number, EIN, from you in order to sell you products and supplies. If you plan to have employees, this federal EIN is necessary and available with the submission of an SS-4. This can be done on-line, by fax, telephone or mail. Each state or province will have required employment reports. The IRS has an excellent source on its website and also a CD available with the needed information. Each state or province will have required employment reports. The majority of states also have state Sales and Use Tax requirements. See your state website or call or write the state Department of Revenue.

As you probably are aware, regulations regarding employees are specific and stringent. IRS Publication 15, Circular E, provides a calendar, easy to read rules and withholding tables. Use it as the employer/employees' bible. Each state will have a publication also. Sales Tax reporting or lack of, and improper employee and payroll issues is detrimental to any business. Ignorance is not an excuse. Research thoroughly.

Child Employment

Even if you do not have other employees, you may be able to deduct reasonable compensation paid to your children for necessary services that they perform for your business, subject to certain restrictions. The amount paid must be reasonable in relation to the child's age and the duties performed. Deciding what is "reasonable" for such deductions requires prudent judgment. As a general rule, the younger the child, the fewer responsibilities that he or she is capable of handling, and, consequently, the smaller the wage deduction that can be justified. The wages paid to a child should be based on the number of hours worked and the value of the child's services to your business.

If your child uses the wages that you paid for his or her own support, your claim for a dependency exemption on your own federal income tax may be threatened. You should, therefore, encourage your child to save this money or use it for purely personal purchases. Also, if your business is unincorporated and your child is under age 18, then his/her wages are exempt from Social Security tax (less than 21 for Federal Unemployment tax).

A spouse or other employees of a farm entity may qualify for Commodity Wages. Again, specific requirements must be met to qualify.

CCRA again has formulas for wages paid to relatives. Called non-arm's length transactions, the calculations differ depending on the degree of relationship. The CCRA Farm Publications, T4003 and RC4060, have the information.

Other Considerations

The CCRA treats some of the capital items differently than the IRS and through the CAIS program; expenses are broke out as allowable and non-allowable.

If you meet the IRS requirements, your health insurance may now be 100 percent deductible against your adjusted gross income. The CCRA has a formula for health insurance deductibility, depending on many factors, including date of policy, age of children, etc.

Canada has the CAIS Program to help farming and agriculture. The CCRA also has exceptions for deferred sales of breeding stock. This allows income from the sale to be used in the year it will most benefit.

Having your records up to date is key to year-end tax planning. Consult with your tax professional to be in the best possible situation. Consider if income needs to be deferred, if possible. Would purchase of equipment or breeding stock help the year-end picture? If the items are to be purchased in the upcoming year, purchasing before the year end may save tax. However, spending money just to save taxes is not a wise use of your resources. Besides affecting your social security wages, money is still being spent. Calculate the "real" cost of the purchase. What is the payback time frame? Will this impact your cash flow negatively? For example, spending $1000, on average, the maximum tax savings would be $350. $650 will still be expended and not available for living expenses. Calculate also the costs incurred or savings realized using a payment plan for necessary purchases.

IRS filing deadlines are April 15th, with any and all tax due at that time. Individuals with 2/3 of their income from farming, may file their tax return on or before March 1st and are relieved of the obligation to make quarterly estimated payments. If no tax is due or an estimated amount is paid, an extension can be granted until August 15 and for extenuating circumstances, with written IRS approval, until October 15th of the filing year. CCRA requires installments to be paid December 31st of the tax year, the remainder of the tax is due April 30th of the filing year and the actual return is due June 15th.

Preparing for the income tax return should not be done just prior to the tax appointment. Receipts and invoices need to be collected in one safe area daily. Keep a large envelope, preferably a waterproof kind, in each vehicle and use the envelope to keep all the slips together. Weekly or monthly, diligently enter all the transactions into some format of income and expense.

A separate farm or business checking account is strongly recommended by the IRS. Compare your income and expenses month to month. Quarterly, double-check that all sales and use tax reports are filed and all payroll obligations are met. By keeping your records up to date, a quarterly and six month summary of profit and loss can be generated. Decisions can be made much quicker and more accurately with reliable information. One month prior to the close of the tax year, year-end tax planning is simpler with eleven months of data. Finally, tally the income and expenses for the entire year. Include all information associated with capital purchases. Insight and thought on the upcoming year will be beneficial in completing the income tax return.

For the most part, individual tax returns that include businesses should be prepared by a tax professional. It is time consuming to stay current with changes in the revenue codes. The tax preparer should consider your current position as well as the future years. Tax planning is done using the advantages allowed by the revenue rulings. However, knowing your business is critical to good decision-making and future planning and projections. Compiling as much of the information as possible means your business can be better managed and your tax professional will better be able to advise you. Bookwork may not be the most fun part of your venture but organizing, recording and doing it well insures the best chance of success.

Note: The above information is supplied by the office of Darlene Eckerman, D. Eckerman Tax Services; to better serve you, an Independent Small Business Owner. All information acquired from clients is kept strictly confidential. To discuss your income taxes and/or how this applies to you, please call for an appointment:

715-623-2520 - phone and fax
eckermst@antigopro.net or darlene.eckerman@teamofdestiny.com

D. Eckerman Tax Services
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The above information is to be used as a guideline to help better prepare you for filing accurate income tax returns. Every effort has been made to insure that all information is complete, accurate and up to date. The information is of a general nature and should not be construed as legal advice. Proper professional assistance should be sought for your particular situation.

References

Further information is available by contacting the Internal Revenue Service.
The website is www.irs.gov.
General information can be obtained by calling 1-800-829-1040.
Forms and publications can be ordered by calling 1-800-829-3676.

Internal Revenue Service reference materials used include:
Publication 225, Farmer’s Tax Guide
Pub 17, Your Federal Income Tax Guide
Pub 334, Tax Guide for Small Business
Pub 378, Fuel Tax Credits and Refunds
Pub 463, Travel, Entertainment, Gift and Car Expenses
Pub 509, Tax Calendars
Pub 533, Self-Employment Tax
Pub 535, Business Expenses
Pub 541, Partnerships
Pub 551, Basis of Assets
Pub 552, Recordkeeping for Individuals
Pub 587, Business Use of Your Home
Pub 946, How to Depreciate Property
Pub 1542, Per Deim Rates

Information on Canadian tax laws is available through the Canada Custom and Revenue Agency. The website is www.ccra.gc.ca
Forms and publications may be ordered by calling 1-800-959-2221

Canada Custom and Revenue Agency reference materials include:
Pub CRA, Canada Income Tax
Pub T4003, Farming Income
Pub RC4060, Farming Income and the CAIS Program
Pub T4002, Business and Professional Income

Handouts

1 - Farm activity codes
- A - Sch F, page 2 IRS
- B - CCRA English
- C - CCRA French

2- Farm Income and Expense
- A - Sch F, cash basis, IRS
- B1 - T2042, CCRA English
- B2 - T1163 CAIS, CCRA English
- C1 - T2042, CCRA French
- C2 - T1163 CAIS, CCRA French

3 - Office and Home Expense
- A - 8829, IRS
- B - T1175, CCRA English
- C - T1175, CCRA French

4 - Business Income and Expense
- A - Sch C, IRS
- B - T2124, CCRA English
- C - T2124, CCRA French

5 - Current or Capital Expenses
- A, B - English
- C - French

SCHEDULE F (Form 1040)

Department of the Treasury Internal Revenue Service (99)

Profit or Loss From Farming

▶ Attach to Form 1040, Form 1041, Form 1065, or Form 1065-B.

▶ See Instructions for Schedule F (Form 1040).

OMB No. 1545-0074

2003

Attachment Sequence No. 14

Name of proprietor	Social security number (SSN)
A Principal product. Describe in one or two words your principal crop or activity for the current tax year.	B Enter code from Part IV ▶
C Accounting method: (1) ☐ Cash (2) ☐ Accrual	D Employer ID number (EIN), if any

E Did you "materially participate" in the operation of this business during 2003? If "No," see page F-2 for limit on passive losses. ☐ Yes ☐ No

Part I **Farm Income-Cash Method. Complete Parts I and II (Accrual method taxpayers complete Parts II and III, and line 11 of Part I.) Do not include sales of livestock held for draft, breeding, sport, or dairy purposes; report these sales on Form 4797.**

1	Sales of livestock and other items you bought for resale	1			
2	Cost or other basis of livestock and other items reported on line 1	2			
3	Subtract line 2 from line 1			3	0
4	Sales of livestock, produce, grains, and other products you raised			4	
5 a	Total cooperative distributions (Form(s) 1099-PATR)	5a	0	5b Taxable amount 5b	0
6 a	Agricultural program payments (see page F-2)	6a	0	6b Taxable amount 6b	0
7	Commodity Credit Corporation (CCC) loans (see page F-3):				
a	CCC loans reported under election			7a	0
b	CCC loans forfeited	7b	0	7c Taxable amount 7c	0
8	Crop insurance proceeds and certain disaster payments (see page F-3):				
a	Amount received in 2003	8a	0	8b Taxable amount 8b	0
c	If election to defer to 2004 is attached, check here ▶ ☐		8d Amount deferred from 2002	8d	
9	Custom hire (machine work) income			9	0
10	Other income, including Federal and state gasoline or fuel tax credit or refund (see page F-3)			10	0
11	**Gross income.** Add amounts in the right column for lines 3 through 10. If accrual method taxpayer, enter the amount from page 2, line 51 ▶			11	0

Part II **Farm Expenses-Cash and Accrual Method. Do not** include personal or living expenses such as taxes, insurance, repairs, etc., on your home.

12	Car and truck expenses (see page F-4 - also attach **Form 4562**)	12	0	25	Pension and profit-sharing plans	25	
13	Chemicals	13		26	Rent or lease (see page F-5):		
14	Conservation expenses (see page F-4)	14		a	Vehicles, machinery, and equipment	26a	0
15	Custom hire (machine work)	15		b	Other (land, animals, etc.)	26b	0
16	Depreciation and section 179 expense deduction not claimed elsewhere (see page F-4)	16	0	27	Repairs and maintenance	27	
				28	Seeds and plants purchased	28	
				29	Storage and warehousing	29	
17	Employee benefit programs other than on line 25	17		30	Supplies purchased	30	
				31	Taxes	31	0
18	Feed purchased	18		32	Utilities	32	
19	Fertilizers and lime	19		33	Veterinary, breeding, and medicine	33	
20	Freight and trucking	20		34	Other expenses (specify):		
21	Gasoline, fuel, and oil	21		a		34a	0
22	Insurance (other than health)	22		b		34b	0
23	Interest:			c		34c	0
a	Mortgage (paid to banks, etc.)	23a		d		34d	0
b	Other	23b		e		34e	0
24	Labor hired (less employment credits)	24	0	f		34f	0

35	**Total expenses.** Add lines 12 through 34f ▶	35	0
36	**Net farm profit or (loss).** Subtract line 35 from line 11. If a profit, enter on **Form 1040, Line 18,** and **also** on **Schedule SE, Line 1.** If a loss, you **must** go on to line 37 (estates, trusts, and partnerships, see page F-6)	36	0

37 If you have a loss, you **must** check the box that describes your investment in this activity (see page F-6).
- If you checked 37a, enter the loss on **Form 1040, line 18,** and **also** on **Schedule SE, Line 1.**
- If you checked 37b, you **must** attach **Form 6198.**

37a ☐ All investment is at risk.
37b ☐ Some investment is not at risk.

For Paperwork Reduction Act Notice, see Form 1040 instructions. **Schedule F (Form 1040) 2003**

(HTA)

Part III **Farm Income - Accrual Method** (see page F-6)

Do not include sales of livestock held for draft, breeding, sport, or dairy purposes; report these sales on Form 4797 and do not include this livestock on line 46 below.

38	Sales of livestock, produce, grains, and other products during the year		38	
39 a	Total cooperative distributions (Form(s) 1099-PATR)	39a 0	39b Taxable amount	0
40 a	Agricultural program payments	40a 0	40b Taxable amount	0
41	Commodity Credit Corporation (CCC) loans:			
a	CCC loans reported under election		41a	0
b	CCC loans forfeited	41b 0	41c Taxable amount	0
42	Crop insurance proceeds		42	0
43	Custom hire (machine work) income		43	0
44	Other income, including Federal and state gasoline or fuel tax credit or refund		44	0
45	Add amounts in the right column for lines 38 through 44		45	0
46	Inventory of livestock, produce, grains, and other products at beginning of the year	46		
47	Cost of livestock, produce, grains, and other products purchased during the year	47		
48	Add lines 46 and 47	48 0		
49	Inventory of livestock, produce, grains, and other products at end of year	49		
50	Cost of livestock, produce, grains, and other products sold. Subtract line 49 from line 48*		50	0
51	**Gross income.** Subtract line 50 from line 45. Enter the result here and on page 1, line 11 ▶		51	0

*If you use the unit-livestock-price method or the farm-price method of valuing inventory and the amount on line 49 is larger than the amount on line 48, subtract line 48 from line 49. Enter the result on line 50. Add lines 45 and 50. Enter the total on line 51.

Part IV **Principal Agricultural Activity Codes**

CAUTION File **Schedule C** (Form 1040), Profit or Loss From Business, or **Schedule C-EZ** (Form 1040), Net Profit From Business, instead of Schedule F if:

- Your principal source of income is from providing agricultural services such as soil preparation, veterinary, farm labor, horticultural, or management for a fee or on a contract basis or
- You are engaged in the business of breeding, raising, and caring for dogs, cats, or other pet animals.

These codes for the Principal Agricultural Activity classify farms by the type of activity they are engaged in to facilitate the administration of the Internal Revenue Code. These six-digit codes are based on the North American Industry Classification System (NAICS).

Select one of the following codes and enter the six-digit number on page 1, line B.

Crop Production

111100 Oilseed and grain farming
111210 Vegetable and melon farming
111300 Fruit and tree nut farming
111400 Greenhouse, nursery, and floriculture production
111900 Other crop farming

Animal Production

112111 Beef cattle ranching and farming
112112 Cattle feedlots
112120 Dairy cattle and milk production
112210 Hog and pig farming
112300 Poultry and egg production
112400 Sheep and goat farming
112510 Animal aquaculture
112900 Other animal production

Forestry and Logging

113000 Forestry and logging (including forest nurseries and timber tracts)

Form **8829**

Department of the Treasury Internal Revenue Service (99)

Expenses for Business Use of Your Home

► **File only with Schedule C (Form 1040). Use a separate Form 8829 for each home you used for business during the year.**

► **See separate instructions.**

OMB No. 1545-1266

2003

Attachment Sequence No. **66**

Name(s) of proprietor(s) | **Your social security number**

Part I — Part of Your Home Used for Business

1	Area used regularly and exclusively for business, regularly for day care, or for storage of inventory or product samples (see instructions)				1	
2	Total area of home				2	
3	Divide line 1 by line 2. Enter the result as a percentage				3	0.00%
	• **For day-care facilities not used exclusively for business, also complete lines 4–6.**					
	• **All others, skip lines 4–6 and enter the amount from line 3 on line 7.**					
4	Multiply days used for day care during year by hours used per day		4	hr.		
5	Total hours available for use during the year (365 days X 24 hours) (see instructions)		5	8,760 hr.		
6	Divide line 4 by line 5. Enter the result as a decimal amount		6	0.0000		
7	Business percentage. For day-care facilities not used exclusively for business, multiply line 6 by line 3 (enter the result as a percentage). All others, enter the amount from line 3 ►				7	0.00%

Part II — Figure Your Allowable Deduction

			(a) Direct expenses		(b) Indirect expenses		
8	Enter the amount from Schedule C, line 29, **plus** any net gain or (loss) derived from the business use of your home and shown on Schedule D or Form 4797. If more than one place of business, see instructions					8	0
	See instructions for columns (a) and (b) before completing lines 9–20.						
9	Casualty losses (see instructions)	9					
10	Deductible mortgage interest (see instructions)	10	0		0		
11	Real estate taxes (see instructions)	11	0		0		
12	Add lines 9, 10, and 11	12	0		0		
13	Multiply line 12, column (b) by line 7			13	0		
14	Add line 12, column (a) and line 13					14	0
15	Subtract line 14 from line 8. If zero or less, enter -0-					15	0
16	Excess mortgage interest (see instructions)	16					
17	Insurance	17					
18	Repairs and maintenance	18					
19	Utilities	19					
20	Other expenses (see instructions)	20					
21	Add lines 16 through 20	21	0		0		
22	Multiply line 21, column (b) by line 7			22	0		
23	Carryover of operating expenses from 2002 Form 8829, line 41			23			
24	Add line 21 in column (a), line 22, and line 23					24	0
25	Allowable operating expenses. Enter the **smaller** of line 15 or line 24					25	0
26	Limit on excess casualty losses and depreciation. Subtract line 25 from line 15					26	0
27	Excess casualty losses (see instructions)			27			
28	Depreciation of your home from Part III below			28	0		
29	Carryover of excess casualty losses and depreciation from 2002 Form 8829, line 42			29			
30	Add lines 27 through 29					30	0
31	Allowable excess casualty losses and depreciation. Enter the **smaller** of line 26 or line 30					31	0
32	Add lines 14, 25, and 31					32	0
33	Casualty loss portion, if any, from lines 14 and 31. Carry amount to **Form 4684,** Section B					33	
34	Allowable expenses for business use of your home. Subtract line 33 from line 32. Enter here and on Schedule C, line 30. If your home was used for more than one business, see instructions ►					34	0

Part III — Depreciation of Your Home

35	Enter the **smaller** of your home's adjusted basis or its fair market value (see instructions)	35	
36	Value of land included on line 35	36	
37	Basis of building. Subtract line 36 from line 35	37	0
38	Business basis of building. Multiply line 37 by line 7	38	0
39	Depreciation percentage (see instructions) Enter date home was first used for business ______	39	0.000%
40	Depreciation allowable (see instructions). Multiply line 38 by line 39. Enter here and on line 28 above	40	0

Part IV — Carryover of Unallowed Expenses to 2004

41	Operating expenses. Subtract line 25 from line 24. If less than zero, enter -0-	41	0
42	Excess casualty losses and depreciation. Subtract line 31 from line 30. If less than zero, enter -0-	42	0

For Paperwork Reduction Act Notice, see page 4 of separate instructions. Form **8829** (2003)

(HTA)

SCHEDULE C
(Form 1040)

Department of the Treasury
Internal Revenue Service (99)

Profit or Loss From Business

(Sole Proprietorship)

▶ **Partnerships, joint ventures, etc., must file Form 1065 or 1065-B.**
▶ **Attach to Form 1040 or 1041.** ▶ **See Instructions for Schedule C (Form 1040).**

OMB No. 1545-0074
2003
Attachment
Sequence No. **09**

Name of proprietor | **Social security number (SSN)**

A Principal business or profession, including product or service (see page C-2 of the instructions) | **B Enter code from pages C-7, 8, & 9** ▶

C Business name. If no separate business name, leave blank. | **D Employer ID number (EIN), if any**

E Business address (including suite or room no.) ▶
City, town or post office, state, and ZIP code

F Accounting method: **(1)** ☐ Cash **(2)** ☐ Accrual **(3)** ☐ Other (specify) ▶

G Did you "materially participate" in the operation of this business during 2003? If "No," see page C-3 for limit on losses ☐ Yes ☐ No

H If you started or acquired this business during 2003, check here ▶ ☐

Part I Income

1	Gross receipts or sales. **Caution.** If this income was reported to you on Form W-2 and the "Statutory employee" box on that form was checked, see page C-3 and check here ▶ ☐	1	0
2	Returns and allowances	2	
3	Subtract line 2 from line 1	3	0
4	Cost of goods sold (from line 42 on page 2)	4	0
5	**Gross profit.** Subtract line 4 from line 3	5	0
6	Other income, including Federal and state gasoline or fuel tax credit or refund (see page C-3)	6	0
7	**Gross income.** Add lines 5 and 6 ▶	7	0

Part II Expenses. Enter expenses for business use of your home **only** on line 30.

8	Advertising	8		19	Pension and profit-sharing plans	19	
9	Car and truck expenses (see page C-3)	9	0	20	Rent or lease (see page C-5):		
				a	Vehicles, machinery, and equipment	20a	0
10	Commissions and fees	10		b	Other business property	20b	0
11	Contract labor (see page C-4)	11		21	Repairs and maintenance	21	
				22	Supplies (not included in Part III)	22	
12	Depletion	12		23	Taxes and licenses	23	0
13	Depreciation and section 179 expense deduction (not included in Part III) (see page C-4)	13	0	24	Travel, meals, and entertainment:		
				a	Travel	24a	0
14	Employee benefit programs (other than on line 19)	14		b	Meals and entertainment — 0		
15	Insurance (other than health)	15		c	Enter nondeductible amount included on line 24b (see page C-5) — 50% — 0		
16	Interest:						
a	Mortgage (paid to banks, etc.)	16a					
b	Other	16b		d	Subtract line 24c from line 24b	24d	0
17	Legal and professional services	17		25	Utilities	25	
				26	Wages (less employment credits)	26	0
18	Office expense	18		27	Other expenses (from line 48 on page 2)	27	0

28	**Total expenses** before expenses for business use of home. Add lines 8 through 27 in columns ▶	28	0
29	Tentative profit (loss). Subtract line 28 from line 7	29	0
30	Expenses for business use of your home. Attach **Form 8829**	30	0
31	**Net profit or (loss).** Subtract line 30 from line 29. • If a profit, enter on **Form 1040, line 12,** and **also** on **Schedule SE, line 2** (statutory employees, see page C-6). Estates and trusts, enter on Form 1041, line 3. • If a loss, you **must** go to line 32.	31	0

32 If you have a loss, check the box that describes your investment in this activity (see page C-6).
• If you checked 32a, enter the loss on **Form 1040, line 12,** and **also** on **Schedule SE, line 2** (statutory employees, see page C-6). Estates and trusts, enter on Form 1041, line 3.
• If you checked 32b, you **must** attach **Form 6198**.

32a ☐ All investment is at risk.
32b ☐ Some investment is not at risk.

For Paperwork Reduction Act Notice, see Form 1040 instructions. **Schedule C (Form 1040) 2003**
(HTA)

RIVER RIDGE STOCK FARM

LARRY & EMILY MEISEGEIER
BRUCE, WISCONSIN, USA

River Ridge Stock Farm has been in Emily's family since 1912 when Emily's Great Grandfather, Rudolph Lundgren traded his farm in Canada for 248 acres along the Chippewa River north of Bruce, Wisconsin. Because of logging in the early 1900's, the river was visible where the buildings were built and Rudolph named the farm "River View Stock Farm."

Rudolph's oldest son Axle, Emily's Grandfather, took over the farm after WWI. He and his wife raised 11 children, the oldest being Emily's mother, with the income from sixteen dairy cows, a few hogs, chickens, and a cash crop of potatoes and cucumbers.

After Axle's retirement in 1968, the farm sat idle and the land was rented to neighbors until 1988 when Emily took over the farm and began raising livestock again.

Larry and Emily joined their flocks in 1994 and began building River Ridge Stock Farm to what it is today.

Today the farm is home to a grade A sheep dairy and growing flock of sheep. Currently the flock numbers over 300 ewes of several breeds including a mix of East Friesian/Lacaune/Dorset with the Booroola gene, Dorper and other hair breeds. Along with these breeds is a small group of Suffolk and Shetland sheep.

The facilities consist of a double twelve pit parlor with "Cass System" stalls, pipeline and six milking units. A three hundred gallon bulk milk tank and 10x12 ft. commercial freezer. The milking facilities are housed in a 26x50 ft. lean-too addition on the old 32x50 ft. dairy barn. Additional buildings include a 24x40 ft. pole shed and a new 30x54 ft hoop type barn built in 2003. The farm can be described as a work in progress with on-going remodeling in the old farm house and continuous fence building.

The flock is managed on rotational grazing paddocks throughout the grazing season. Dry hay, baleage and silage along with small grain screenings are fed during the cold months. Milking ewes are fed a protein supplement in the parlor during milking.

A day one weaning is practiced for milking ewes, and lambs are raised on milk replacer, grain and alfalfa hay.

During the 2004 production season, approximately 130 ewes were milked with a production of 45,000 pounds of milk.

Dairy goats are also milked at River Ridge with the milk being used to feed lambs, kids, beef calves and hogs.

UDDER MORPHOLOGY AND EFFECTS ON MILK PRODUCTION AND EASE OF MILKING IN DAIRY SHEEP

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Summary

Mammary morphology is generally accepted as a key factor for machine milkability and its inclusion in dairy sheep improvement programs has been widely recommended (Fernandez et al., 1997; Caja et al., 2000). The anatomical and morphological characteristics of the mammary gland and its importance for milk production, machine milkability and manageability in dairy sheep have become of greater interest from farmers to researchers. The sheep udder is an exocrine epithelial gland mainly constituted by tubulo-alveolar parenchyma with alveoli and well differentiated cisterns. Two anatomical compartments are considered for milk storage: alveolar and cisternal, the large-cisterned animals being more efficient milk producers. The evaluation of external morphology by using udder typology, objective udder measurements and linear scores in practice is also discussed. Recent methodology using ultrasonography has been applied for the study of the mammary gland, providing a satisfactory non invasive method for determination of milk storage characteristics in dairy species. Machine milkability is evaluated by milk fractioning and milk emission curves during milking. Both criteria are discussed and analyzed in sheep breeds of different milk yield. Relationship between morphological and productive traits in dairy sheep is analyzed as a result of anatomical and physiological characteristics. Phenotypic and genetic correlations indicate that selection for milk yield will produce worse udder morphology, resulting in udders which are inadequate for machine milking, especially in highly selected herds. Teat and cistern characteristics appear to be the most limiting factors in machine milkability. Some selection pressure on udder traits in long-term breeding programs needs to be considered and the use of linear udder traits is recommended in practice to improve udder morphology and milkability. Knowledge of the relationship of udder morphology traits with milk production and milking time in U.S. dairy ewes is needed to provide producers with recommendations for culling strategies based on ewe udder traits. The effectiveness of the European scoring systems for dairy-meat breeds cross ewes in U.S. dairy sheep farms is discussed.

Introduction

The current breeding goal for milkability in dairy cows, goats and sheep is focusing on an improvement of the adaptation of these animals to the machine milking process, and its influence on milking time and farm economics. According to Labussiere (1988), even if the main quality of a dairy ewe is its production level, it is essential to be able to extract rapidly the milk retained in the udder, not only with a minimum of manual interventions (udder stimulation, machine stripping and hand stripping), but also at times which are not too restricting and sufficiently spaced to allow the practice of omitting one milking per day (Sunday, end of lactation, etc.).

The interest in the dairy sheep udder has increased in the last few years in which anatomy has been explored in depth (Ruberte et al., 1994b; Caja et al., 1999; Carretero et al., 1999), and a linear scoring system has been developed to select udders with good “milkability” in Spanish and Italian breeds (De la Fuente et al., 1996 and 1999; Carta et al., 1999), as well as the evaluation of its genetic parameters (Gootwine et al., 1980; Mavrogenis et al., 1988; Fernández et al., 1995; 1997; Carta et al., 1999). Moreover, given the negative effects observed in udder morphology as a result of the increase in milk yield, main udder traits between breeds of different yielding (Rovai et al., 1999; Rovai et al., 2003) or between genetically isolated lines of the same breed (Marie et al., 1999) are under comparison.

Shape and size of the udder and teat have been shown to be related to milk yield (Labussière et al., 1981; Labussière, 1988; Fernández et al., 1995, 1997; Carta et al., 1999; Rovai et al., 1999) and milk flow rate (Marnet et al., 1999; Marie-Etancelin et al., 2002) in Spanish and French dairy breeds. However, the repeatability and heritability of udder morphology traits and their relationships with milk yield and milking time in U.S. dairy ewes are needed so that recommendations can be given to producers on whether or not udder morphology should be considered in culling and selection decisions. A preliminary study of udder traits with U.S. dairy ewes was conducted by McKusick et al. (2000) and continued with a more detailed udder characterization by Rovai et al. (2003).

The American dairy sheep industry started by milking breeds of sheep commonly available in the U.S and selected for lamb and wool production. Strict animal health regulations on the importation of live sheep, ram semen, and sheep embryos was a major obstacle to importations of genetic material from breeds of selected sheep from other countries. However, due to the persistency of producers and some university researchers, a small amount of genetic material in the form of semen and embryos of two dairy sheep breeds (East Friesian of German origin and Lacaune of French origin) was imported into Canada and the U.S. Since the dairy sheep industry is expanding at a very satisfactory rate, the need of care to the economically important traits as high milk yield, milking time, and an ideal udder conformation are crucial to a better milking performance and consequently minor milking labor costs of the future generations.

This paper describes the particularities of the dairy sheep udder and summarizes the current implications of udder morphology on machine milkability with special emphasis on dairy-meat cross ewes under U.S. production conditions.

Mammary gland in the dairy ewe

The mammary gland is an exocrine epithelial gland, exclusive to mammal species, which is quantitatively and qualitatively adapted to the individual growth requirements and behavior of each specie. It shows histological similarities to other epithelial glands such as the salivary and sweat glands. Milk secretion is described as the activity of a cellular factory (the lactocyte) which transforms itself into the product (the milk). The entire process is controlled by integrated neuro-endocrine and autocrine systems. It mainly develops during pregnancy and early lactation, and regresses very quickly after dry-off.

***Origin and development of the mammary gland*:** The mammary gland is formed by two main structures: the parenchyma and the stroma. The partitioning between both structures defines the anatomical and functional characteristics of each mammary gland. The parenchyma is the secretory part of the gland and it is made up of tubulo-alveolar epithelial tissue, coming from the ectoderm layer of the embryo, and it consists of the tubular (ductal) and alveolar systems. The stroma is formed by other complementary tissues of mesodermic origin such as: vessels (blood and lymph) and different tissues (adipose, connective and nervous). Both structures develop very early from the ventral skin of the embryo and half-way through the pregnancy reaching a total of eight pairs of isolated mammary buds in all mammal embryos (Delouis and Richard, 1991).

At birth, the sheep udder shows clearly differentiated cisterns (*Sinus lactiferus*) and teats (*Papilla mammae*) and very incipient development of the ductal system, with few primary ducts surrounded by numerous stroma forming cells. After birth the udder grows at the same rate as the body (isometric growth) until puberty, with proliferation and branching of the secondary ductal system. Puberty in most species is the quickest period of growth for ducts and stroma of the mammary gland (positive allometric growth), as a result of the action of sexual hormones. Nevertheless, the future milk capacity of the udder can be impaired at this stage by an excessive growth of the stroma (mainly adipose and connective tissues) in comparison to the parenchyma (tubulo-alveolar epithelium). This critical phase occurs earlier in sheep than in cattle, with differences between breeds. Thus, the parenchyma growth ends in sheep before puberty and, as a consequence, mammogenesis in sheep will be affected by nutrition during and after the positive allometric growth phase (Bocquier and Guillouet, 1990). The critical period for mammogenesis is from 2 to 4 months old. Moreover an early onset of puberty will bring forward the decrease in mammary development. According to Johnson and Hart (1985) and McCann et al. (1989), a relative low growth rate (50% of high rate) from weaning (wk 4) to the end of rearing period (wk 20) will increase the parenchyma growth and the milk production in the first lactation in non dairy ewe-lambs. No negative effects were observed at the beginning of puberty. Nevertheless a low growth rate before weaning will also negatively affect mammogenesis (McCann et al., 1989). Unfortunately there is no detailed information available on dairy sheep, but Bocquier and Guillouet (1990) reported that the restriction of concentrate in Lacaune ewe-lambs, after they reach approximately 28 to 30 kg, increases milk yield by 10% in the first lactation.

During the first and subsequent pregnancies, the parenchyma shows an allometric growth where the placenta plays an important role producing a specific ovine chorionic somatotropin hormone after day 60 of pregnancy and dependent on prolificacy. Mammogenesis starts clearly in sheep between day 95 and 100 of pregnancy, with detection of lactose (start of lactogenesis) after day 100 (Martal and Chene, 1993).

The presence of secretory lobes with alveolus in the extremes of the ducts can be observed in the second half of pregnancy. Delouis and Richard (1991) estimate a change from 10 to 90% in the relative weight of the parenchyma during pregnancy, where the lobulo-alveolar development of epithelial cells takes the place of the adipose tissue. The inverse process occurs during the dry period, with a complete disappearance of the alveoli in the ewe after 3 to 4 weeks, and its replacement by adipocytes (Hurley, 1989). Moreover during the involution process the mammary gland is invaded by macrophages and lymphocytes, the latter being essential for the production of immunoglobulins in the synthesis of colostrum in the next pregnancy.

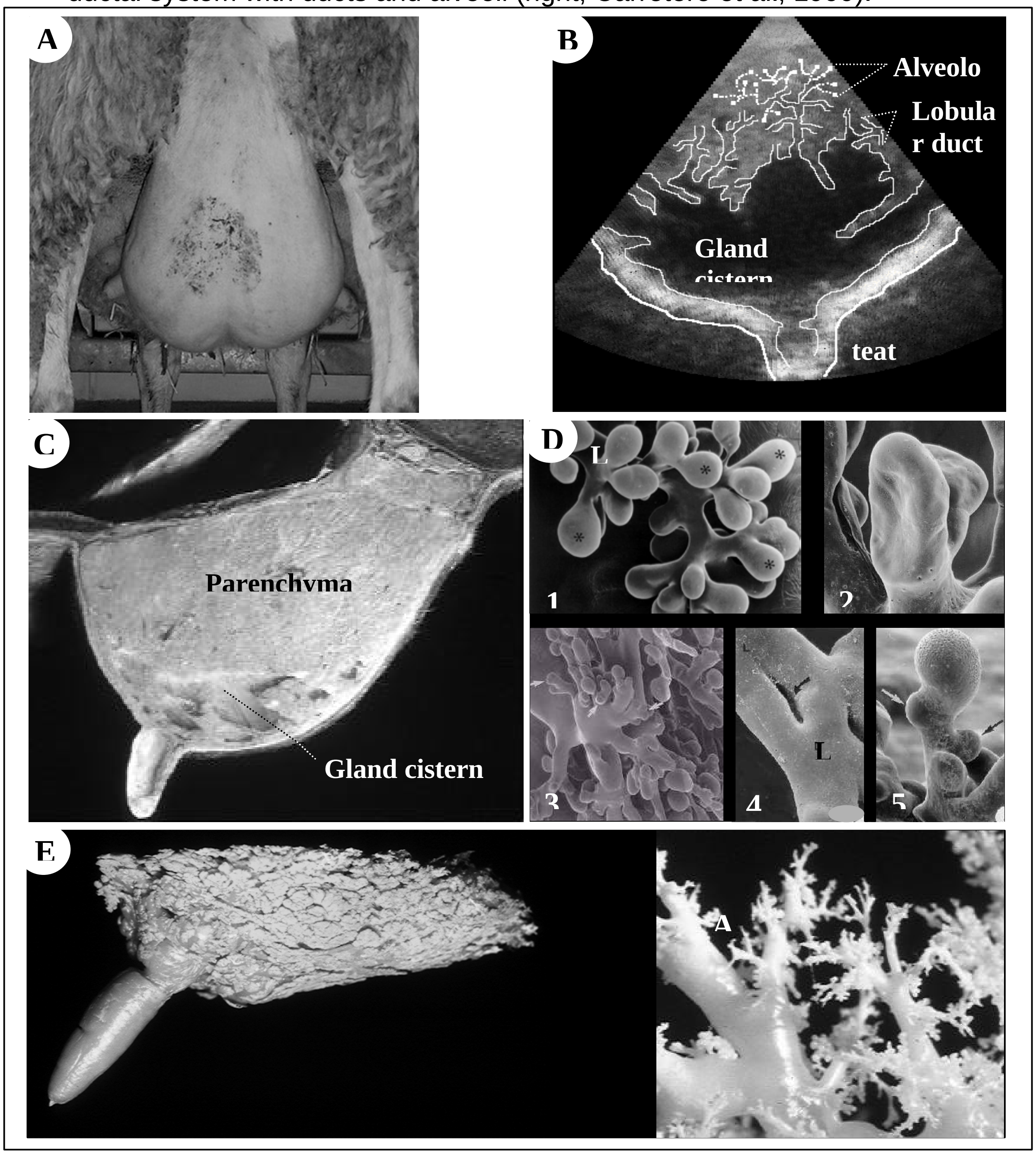
Internal structure of the mammary gland**:** The internal structure of the ewe udder described reveals the presence of two independent mammary glands under a unique skin bag, each of them wrapped by a bag of fibroelastic connective tissue (*Apparatus suspensorius mammarum*) and separated by a clearly defined and intermediate wall of connective tissue (*Ligamentum suspensoris uber*; Turner et al., 1952; Barone, 1978; Tenev and Rusev, 1989; Ruberte et al., 1994b). The strength of this ligament normally produces the presence of an intermmamary groove (*Sulcus intermammarius*) between each gland which plays an important role maintaining the udder tightly attached to the ventral abdominal wall. Each half udder shows internally a typical tubulo-alveolar structure with a big cistern (*Sinus lactiferus*) divided in two parts: glandular cistern (*S. l. pars glandularis)* and teat cistern (*S. l. pars papillaris*). Both cisterns are separated by a muscular sphincter of smooth muscular fibers, traditionally known as the cricoid fold, important for the milk drainage. It also helps to keep the teat and gland morphology divided during machine milking to avoid the appearance of cluster climbing. The cricoid sphincter is normally missing in goats and it is not very effective in the conic teat udders, which are not favorable for machine milking. Size and form of the gland cistern vary according to the breed and milking ability of the sheep, being greater and plurilocular in high yielding ewes (Figure 2). Another sphincter with smooth muscular fibers is present around the streakcanal (*Ductus papilaris*) in the distal part of the teat, connected to the exterior by a unique orifice (*Ostium papilare*).

The last mammary gland structures in the parenchyma are the secretory lobes, consisting of much branched intralobular ducts and alveoli. The alveolus is the secretory unit of the mammary gland and consists of a bag of a unique layer of specialized cubic epithelial cells (the lactocytes) with an inside cavity (the lumen) in which the milk is stored after secretion.

The mammary gland stores the milk extracellulary and this storage can be explained using a model of two anatomical compartments (Wilde et al., 1996): ‘Alveolar milk’ (secreted milk stored within the lumen of alveolar tissue) and ‘Cisternal milk’ (milk drained from the alveoli and stored within the large ducts, the gland cistern and teat cisterns). Short-term autocrine inhibition of milk secretion in the mammary gland has been related to cisternal size, the large-cisterned animals being in general more efficient producers of milk and more tolerant to long milking intervals and simplified milking routines (Wilde et al., 1996).

The external morphology and anatomic ultrastructure of the mammary gland with its canalicular system are shown in detail in the Figure 1.

Figure 1. Dairy sheep mammary gland. A) Dairy ewe udder; B) Cistern ultrasound; C) Sheep udder anatomy; D) Microscopy images from epoxy casts of: 1, lobular duct (L) and alveoli (*), 2, collapsed alveolus, 3, alveoli, 4, intussusceptive growth in a lobular duct, 5, alveolar sprouts; E) Cast of a dairy sheep udder obtained by the epoxy injection and corrosion method (left) and detail of the ductal system with ducts and alveoli (right; Carretero et al., 1999).



Morphology of the mammary gland

The anatomy and morphology of the sheep udder has been well known for many years (Turner, 1952; Barone, 1978), and selection on udder morphology has been assayed. Early works on the relationship between udder characteristics and milking performance in dairy ewes were carried out in the 70's and early 80's (Sagi and Morag, 1974; Jatsh and Sagi, 1978; Gootwine et al., 1980; Labussière et al., 1981) as a consequence of the efforts to adapt the ewe to the machine milking.

With this aim an international protocol (M4 FAO project) for dairy sheep udder evaluation in the Mediterranean breeds was performed as an initiative from Prof. Jacques Labussière (Labussière, 1983, 1988). Based on this standardized protocol, the udder of many dairy sheep breeds was systematically studied in relation to machine milking (Casu et al., 1983; Fernández et al., 1983a; Gallego et al., 1983a; Hatziminaoglou et al., 1983; Labussière et al., 1983; Pérez et al., 1983; Purroy and Martín, 1983) and following symposiums (Arranz et al., 1989; Kukovics and Nagy, 1989; Rovai et al., 1999) in Europe, and also in America (Fernández et al., 1999; McKusick et al., 1999).

According to Labussière (1988), the milk production is always correlated to size of the udder, however, voluminous cistern cavities to assure the accumulation of the milk secreted over long milking intervals and teats implanted vertically at the lowest point of the cistern should be also considered to improve the milkability of dairy sheep.

***Udder typology*:** Mammary morphology has been described as an important factor in the machine milkability of dairy ewes (Labussière et al., 1981; Gallego et al., 1983a; Fernández et al., 1995). The first practical utilization of udder morphology on dairy sheep was made by using tables of udder typology in Awassi and Assaf (Sagi and Morag, 1974; Jatsch and Sagi, 1978), Sarda (Casu et al., 1983) and Manchega ewes (Gallego et al., 1983a, 1985), all of them based on four main udder types. These typologies were later adapted to the Latxa breed (Arranz et al., 1989) and Hungarian Merino and Pleven (Kukovics and Nagy, 1989). A comparative table of these typologies can be observed in Figure 2. The typology used in Sarda was evaluated in field conditions (Casu et al., 1989) and extended to seven udder types mainly based on teat position and cistern size (Carta et al., 1999) with the aim of improving the small discriminating capacity of the previous typologies (Figure 2). Typology is recommended as a useful tool for the screening of animals, i.e. in the standardization of machine milking groups or in the choice of ewes at the constitution or acquisition of a flock, and for culling of breeding animals (Gallego et al., 1985; Carta et al., 1999). The evaluation of sheep udders by udder types is easy, quick and repeatable with trained operators (Carta et al., 1999; De la Fuente et al., 1999). However, the inclusion of non-subjective measurements and linear evaluation needs to be considered for the study of machine milkability of the dairy ewes.

The average milk production tend to be superior in Type I udders due probable to the negative relation between milk production and teat insertion (Rovai, 2001). On the other hand, Type IV showed an inferior milk yield due to the unshaped udder presented by the ewes in this category (Gallego *et al*., 1983a; Rovai, 20001). Most of the time, ewes assigned to Type IV refers to animals with mastitis, field accidents, etc.

The udder typology proposed by Gallego et al. (1983a) was evaluated in U.S. ewes of dairy-meat crosses (Table 1) and compared with previous studies on other breeds (Table 2). This system was designed to classify the ewes more adapted to machine milking using teat angle insertion, and is based on check and assigned udders into four categories (Figure 2): **Type I** = horizontal teats; **Type II** = teats at 45 degrees; **Type III** = vertical teats – most desirable (“udder machine”); **Type IV** = misshaped udder. Also the presence or not of the suspensor ligament in the udder (1: yes and 0: no).

Figure 2. Udder scoring method proposed for different dairy sheep breeds (Elaborated by Peris, 1994).

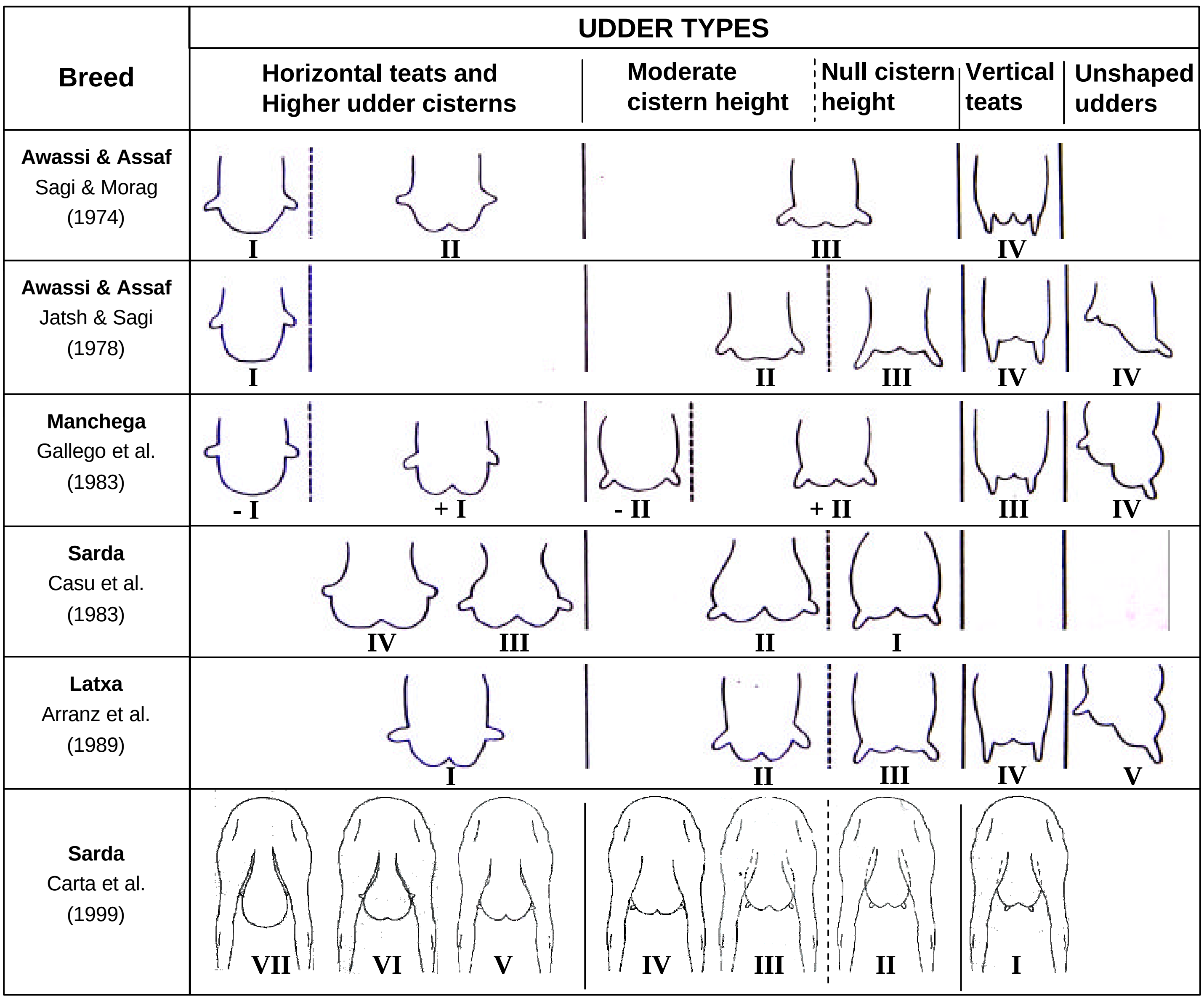


Table 1. Udder typology and the presence or not of the suspensor ligament (IG) in commercial and university U.S. dairy-cross ewe's farms.

Flock [1]	Ewes crosses		Udder type (%)				IG (%)	
		n	I	II	III	IV	1	0
A	**EF** (10 to 50%)	166	**6** (4%)	**123** (74%)	**29** (17%)	**8** (5%)	**166** (100%)	**0**
B	**EF** (10 to 75%)	177	**19** (11%)	**113** (64%)	**32** (18%)	**13** (7%)	**167** (94%)	**10** (6%)
C		194	**27** (14%)	**132** (68%)	**28** (14%)	**7** (4%)	**189** (97%)	**5** (3%)
D[1]	**EF** (75%)	27	**5** (18%)	**21** (78%)	**1** (4%)	**0**	**20** (74%)	**7** (26%)
	EF (50%)	48	**10** (21%)	**36** (75%)	**1** (2%)	**1** (2%)	**38** (79%)	**10** (21%)
	LC (50%)	26	**13** (50%)	**12** (46%)	**1** (4%)	**0**	**26** (100%)	**0**
	EF-LC (¼ EF– ½ LC)	18	**5** (28%)	**13** (72%)	**0**	**0**	**5** (28%)	**13** (72%)

A, B, C are commercial U.S dairy fams, and D is a University farm.
[1] Measurements done at week 11 of lactation.

As shown in Table 1 udders of Type II were more frequent than other types in all flocks. Commercial-D flock also had a high percentage of ewes with udders of Type I which may be the result of the presence of Lacaune ewes. These results are in agreement to Rovai (2001) where comparing 232 ewes of Manchega and Lacaune breeds, found a similar frequency of Type II udders in both breeds, as shown in Table 2. However, Manchega breed showed a higher incidence of Type III (more adapted to machine milking), whereas Lacaune dairy sheep presented a larger percentage of Type I udders, with teats placed more horizontally. The incidence of Type IV, which implies a worse milkability, was very low due the culling of these ewes in this flock.

The frequency of udder types (mainly Type I) tend to increase according to the age of the ewe, although it seems not be affected by the state of lactation (Rovai, 2001). An ideal proposal would be to assess udder morphology during the first lactation, allowing remaining in the herd only those ewes with udders adapted to machine milking.

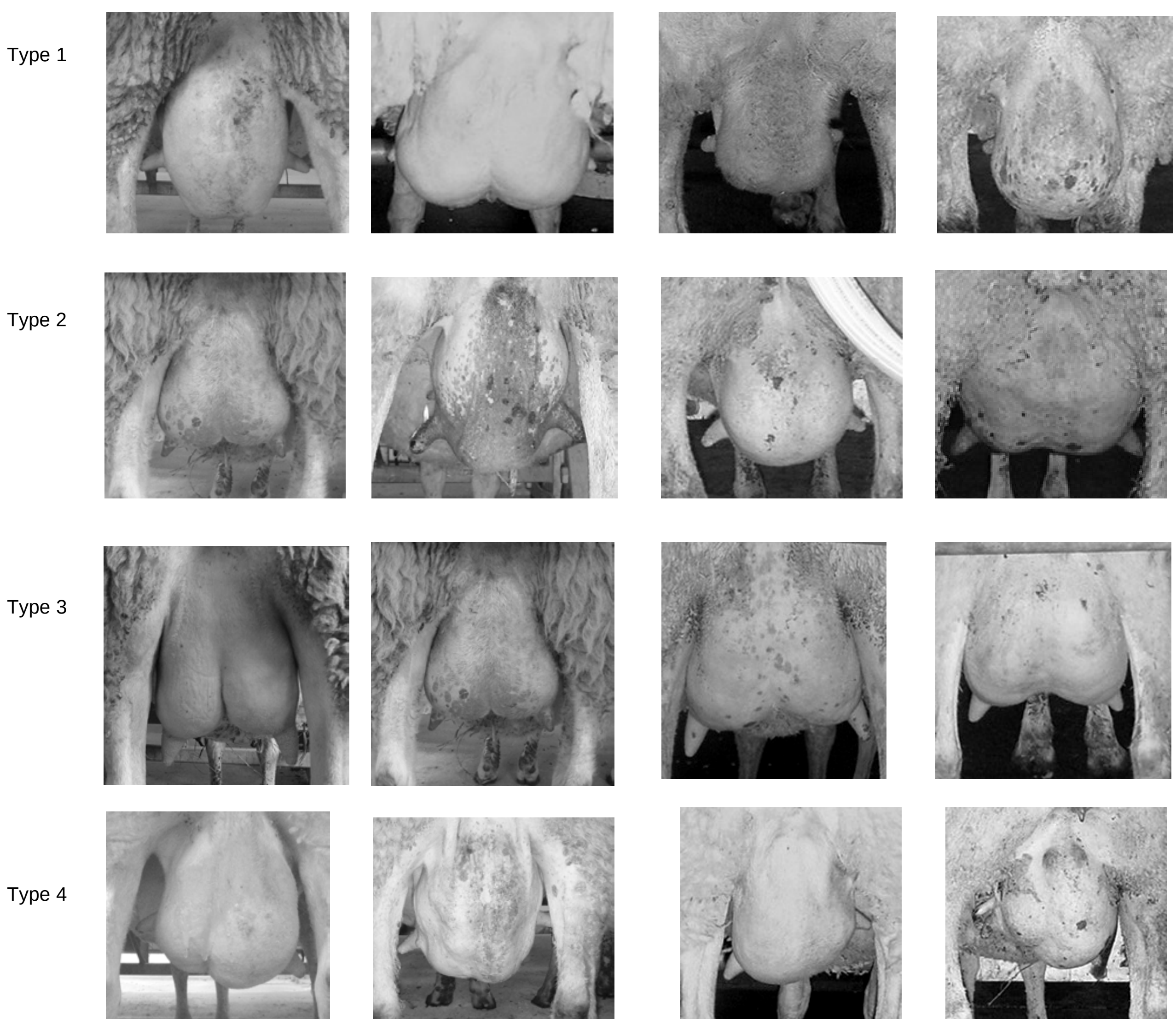
Table 2. Udder typology from different sheep breeds.

Ewe breeds	Udder type (%)				Authors
	I	II	III	IV	
Manchega	19.2%	56.2%	14.3%	10.3%	Gallego *et al*. 1983a
	11.6%	52.2%	2.9%	33.3%	Fernández (1985)
	8.6%	75.0%	13.6%	2.8%	Rovai, 2001
Lacaune	15.7%	71.6%	8.7%	4.0%	Rovai, 2001
	24.5%	67.9%	7.4%	0.2%	Rovai, 2001[1]

[1] A purebreed Lacaune flock from the experimental research station "Lafage", Roquefort (France).

Some examples of udders from U.S. dairy-cross ewes are shown in Figure 3. As we can observe the udders can be easy classified into the described udder typology.

Figure 3. *Examples of types of udder from commercial and university U.S. dairy-cross ewe's farms classified according the typology proposed by Gallego et al. (1983a).*



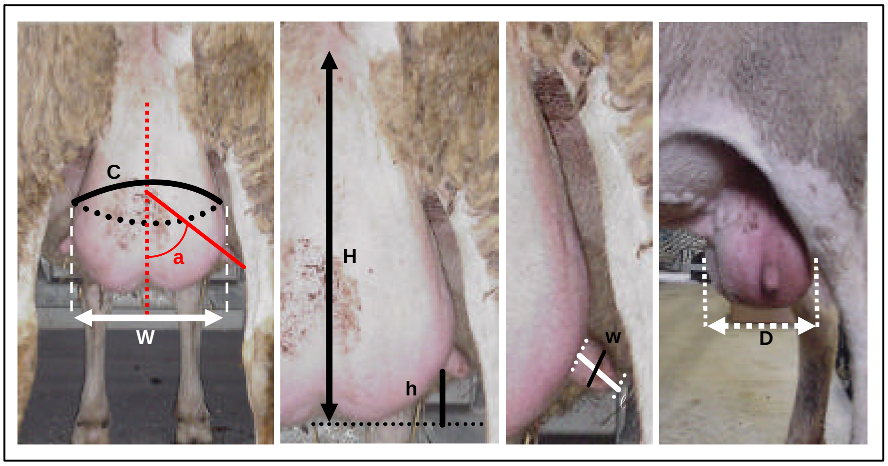
Udder measurements: The use of objective measurements for the characterization of the dairy sheep udder and its relations with other productive traits has been undertaken by different authors. The importance of the mammary traits on milk yield and milking routine has been studied in the dairy ewe since the development of machine milking, and its evaluation during lactation can be significant for obtaining a positive genetic response in the milkability of dairy ewes. Until now, the mammary traits have not been considered as a primary objective in dairy sheep selection. Nevertheless, these traits determine several aspects of the machine milking and manageability (time of milking, falling off of the clusters, difficulty of lambs to find the teats,...).

The continuous nature of the measurements increases the discriminating capacity of each variable and the significance of correlation with the productive traits. The methodology generally used corresponds to the standardized protocol of Labussière (1983) with small variations incorporated in some cases (Gallego et al., 1983a; Fernández et al., 1983, 1995; Rovai, 2001).

Udder size (depth, width, length, and circumference), teat size (length and width), teat angle, and cistern height used to be measured *in vivo* using a ruler and protractor as shown in Figure 4. The main traits which can be grouped and explain an important amount of the variability of the mammary morphological traits are: 1) *Udder size*: height, depth and width; 2) *Teat size*: length and width; 3) *Teat insertion angle and cistern height*.

The repeatability of udder measurements made according to this methodology is low for udder dimensions (r= 0.17 to 0.18), medium for teat dimensions and teat position (r= 0.45 to 0.52), and high for teat angle (r= 0.65) and cistern height (r= 0.77), as calculated by Fernández et al. (1995) in the Churra dairy breed.

Figure 4. Mammary traits, rear and lateral view.



C: udder circumference, **a**: teat angle, **W**: udder width, **H**: udder depth, **h**: cistern height, **l** and **w**: length and width of the teat and **D**: udder depth.

Udder shape and size is related to milk yield and milking time in specialized dairy sheep breeds in Europe (Gallego et al., 1983a; Fernández et al., 1983 and 1995; Rovai, 2001). The comparison of main udder measurements among dairy-meat cross ewes under U.S. production conditions was also studied, and are in accordance with previous studies on different breeds of ewes. Table 3 shows that milk yield and udder traits were different between U.S. dairy cross ewes.

Milk yield was highest in East Friesian-Lacaune ewes, increased with age of ewe, and decreased through lactation. Lacaune ewes had the shortest teats and the highest teat insertion. Cistern height and udder size were larger in Lacaune and East Friesian-Lacaune ewes than in the other two breed groups and corresponded with their greater milk production. Udder size and teat size increased with parity number, reaching their maximum in ewes of three or more lactations. Udder size decreased through lactation while teat angle and cistern height increased.

In general, the stage of lactation produced significant effects on all udder traits in accordance with previous studies on udder morphology. Udder traits increased according to parity and maximum was observed on third and more parity ewes, however, age effects only showed a tendency in teat angle and cistern height.

Table 3. Mean values of udder traits and effects of breed in U.S. dairy-cross ewes (Rovai et al., 2003).

Traits		**Ewe crosses**			
		EF (½ EF)	**EE** (¾ EF)	**LC** (½ LC)	**EF-LC** (¼EF-½LC)
Ewes	*n*	49	27	26	18
Milk yield	liters	1.2 [a]	1.3 [a]	1.2 [a]	1.6 [b]
Udder size					
depth	cm	8.7 [a]	8.8 [a]	9.1 [a]	10.3 [b]
width	cm	13.5 [a]	13.8 [a]	14.0 [ab]	14.7 [b]
length	cm	21.2 [a]	21.2 [a]	21.8 [ab]	23.1 [b]
circumference	cm	42.2 [a]	42.5 [a]	43.4 [a]	46.7 [b]
Teat size					
length	cm	3.4 [a]	3.3 [a]	3.0 [b]	3.4 [a]
width	cm	1.5 [a]	1.5 [a]	1.4 [b]	1.5 [a]
Teat angle	degrees	51 [c]	48 [a]	59 [b]	54 [c]
Cistern height	cm	3.3 [a]	3.0 [a]	3.8 [b]	4.0 [b]

[a,b,c] Within sheep group per trait, values with a different superscript are different ($P < 0.05$).

These results agree with those obtained previously in different breeds (Labussière, 1988; Fernández et al., 1983, 1995; Casu et al., 1983; Gallego et al., 1983a; Labussière et al., 1983; Fernández et al., 1989a, 1995; Rovai, 2001) although teat angle was affected by stage of lactation in other references.

In regard to the correlation coefficients between udder traits, three natural groups can be distinguished as indicated by Fernández et al. (1995): 1) udder size (height and width), which are high and positive; 2) teat size (width and length), which are medium and positive; and 3) cistern height and teat placement (position and angle) which are medium and positive but show low and negative correlation with teat and udder sizes. As udder width increases, cistern height and teat angle decrease; and, as udder height increases, cistern height and teat angle also increase.

When morphological traits are related to milk yield the greatest effects are observed for udder width and height and commonly tendencies are only observed for the remaining traits (Gallego et al., 1983a; Labussière et al., 1983; Fernández et al., 1989a, 1995; McKusick et al., 1999; Rovai et al., 2003). Big volume and cisterned udders produce more milk. Main effects of teat traits are related to milk fat (McKusick et al., 1999) and milk emission during milking (Fernández et al., 1989a; Marie et al., 1999).

As a conclusion, the most significant and repeatable udder traits agreed by different authors for a wide sample of sheep dairy breeds are:

- Teat dimensions (length) and placement (angle)
- Udder height and width
- Cisterns height

Analysing the results on Table 3 we can also observe that the different cross-breeds ewes present enough differences in udder morphology to be grouped according to udder type, making the possibility of establishing a universal udder classification valid for all breeds almost impossible.

Linear scores**:** The main drawback of the udder typologies is their use for the estimation of the genetic value of breeding animals and when genetic and environment effects need to be break down for selection. This problem has been solved in dairy sheep, as in dairy cows and goats, by using a breakdown system in which independent udder traits are based on 9-point scale per trait as shown in Table 4 (De la Fuente et al., 1995).

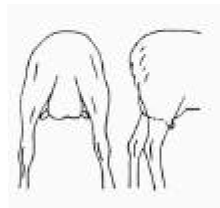
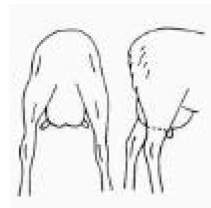
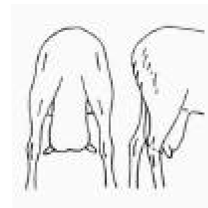
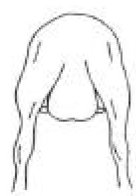
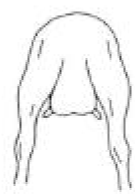
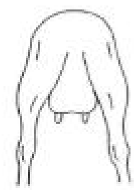
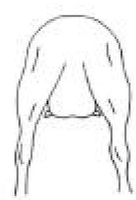
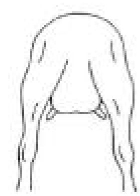
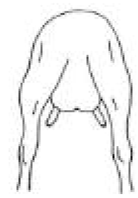
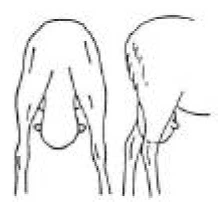
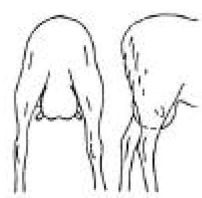
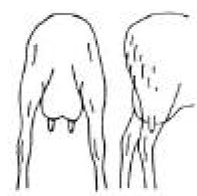
The system is based on the following udder traits: **udder depth** (from the perineal insertion to the bottom of the udder cistern), **teat angle** (teat insertion angle with the vertical), and **teat length** (from the gland insertion to the tip), and also includes an expanded typology to evaluate the whole udder shape, in accordance with the previously described optimal criteria for udder types. Each udder trait is evaluated independently by using extreme biological standards.

The desirable value is in some cases the highest score (i.e. teat angle: vertical teats that scored 9 will reduce cluster drops and will make easier the milk drainage) or the average score in others (i.e. teat length: medium size teats scored 5 and agree with a uniform cluster length). In udder height, given its positive relationship with milk production an average score will also be preferable. This linear methodology has been used in Spain for the evaluation of different flocks (27 flocks and 10,040 ewes) of Churra, Manchega and Latxa dairy ewes (De la Fuente et al., 1999), partially in France for Lacaune breed (Marie et al., 1999), and in U.S. for the evaluation of the machine milking ability of East Frisien and Lacaune crossbred ewes (Rovai et al., 2003).

The linear udder scoring systems evaluated in U.S. included flocks of dairy-meat ewe crosses from three commercial dairy sheep farms and one university farm, as shown in Table 5. Percentage of East Friesian breeding had no effect on udder trait scores in the commercial farms. However, Lacaune ewes from University farm had the most horizontal teats. As we can observe in Table 5, Lacaune crosses tended to have udders less suited to machine milking compared to East Friesien crosses; as assessed by the European scoring systems.

Udder depth score increased significantly as parity number increased in all farms, reaching the maximum values in third and greater lactations. Udder depth score decreased through lactation in the commercial farms, and remained constant in the University flock. Ewes in later stages of lactation tended to have more horizontal teats and faulty udders than ewes in earlier stages of lactation. Within all genotypes and farms, positive and significant correlations were observed between udder depth scores and milk yield (0.20 to 0.46). High correlations were observed also between udder shape and teat angle scores (0.80 to 0.93), and also between udder depth score and milk production.

Table 4. Linear scores for the evaluation of main udder morphological traits in dairy sheep (De la Fuente et al., 1999).

Morphological trait	Score (1 to 9)		
	1 (Shallow)	5 (Average)	9 (Deep)
Udder depth or height			
	1 (Horizontal)	5 (45 degrees)	9 (Vertical)
Teat angle			
	1 (Short)	5 (Average)	9 (Long)
Teat length			
	1 (Faulty)	5 (Average)	9 (Ideal)
Udder shape			

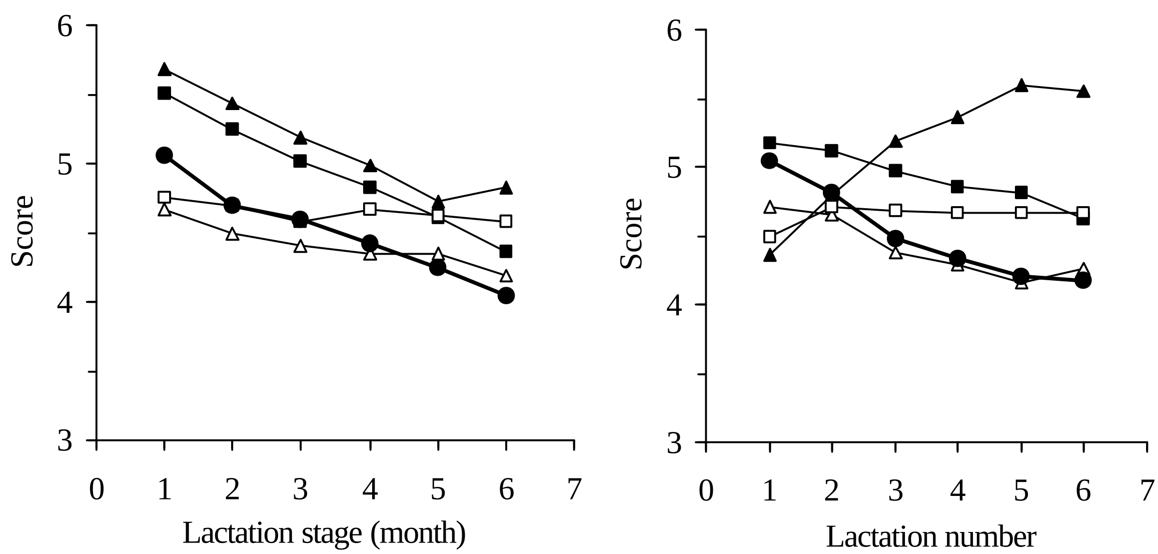
The results obtained for Spanish breeds, according to lactation stage and parity effects, are shown in Figure 5. In regard to lactation stage, all linear scores decreased as lactation progressed, udder height and udder attachment being the traits which showed the greatest decrease during lactation, while teat size was only slightly modified. This evolution agrees with the loss of udder volume and milk yield but indicates a deterioration of udder morphology for machine milking as indicated by udder shape. Only udder height was improved. Regarding lactation number, udder height increased dramatically in the first lactations, while other traits decreased and teat size was steadily constant. As a consequence, udder shape deteriorated and its score decreased rapidly from first to third lactation and stabilized thereafter.

Table 5. Linear udder scores in U.S. dairy-cross ewes farms (Rovai et al., 2003).

Flock	Farm	Ewe crosses	*n*	Traits		
				Udder depth	***Teat angle***	***Udder shape***
A	commercial	**EF** (10 to 50%)	177	4.4	4.9	5.0
B	commercial	**EF** (10 to 75%)	166	4.6	5.3	5.5
C	commercial		197	3.8	5.2	5.1
D	university	**EF** (50 or 75%)	120	5.1 [a]	4.3 [a]	3.8
		LC (50%)		5.3 [a]	3.3 [b]	3.1
		EF-LC (¼ EF– ½ LC)		6.0 [b]	3.9 [a]	3.7

[a,b] Within farm C, values with a different superscript are different (*P* < .05).

Figure 5. Evolution of linear scores of main udder traits in Spanish dairy sheep: ? , udder height; ¦ , udder attachment; ?, teat angle; ?, teat length; and, ?, udder shape (elaborated from De la Fuente et al., 1999).



The values of linear scores calculated by Fernández et al. (1997) in the Churra dairy breed (Table 6) were sufficiently repeatable (r= 0.48 to 0.64) and showed intermediate heritability values (h^2=0.16 to 0.24) as reported in cattle. Coefficients of variation ranged between 18 and 37%. The authors indicate that a single scoring per lactation would be sufficient in practice.

Table 6. Genetic parameters of linear udder traits in dairy sheep (Fernández et al., 1997).

Trait	Heritability (h^2)	Repeatability (r)	Correlation with milk yield	
			Phenotypic (r_p)	Genetic (r_g)
Udder height	0.16	0.51	0.40	0.82
Udder attachment	0.17	0.48	–0.01	–0.02
Teat placement	0.24	0.64	–0.04	–0.34
Teat size	0.18	0.54	0.03	–0.16
Udder shape	0.24	0.62	0.03	–0.26

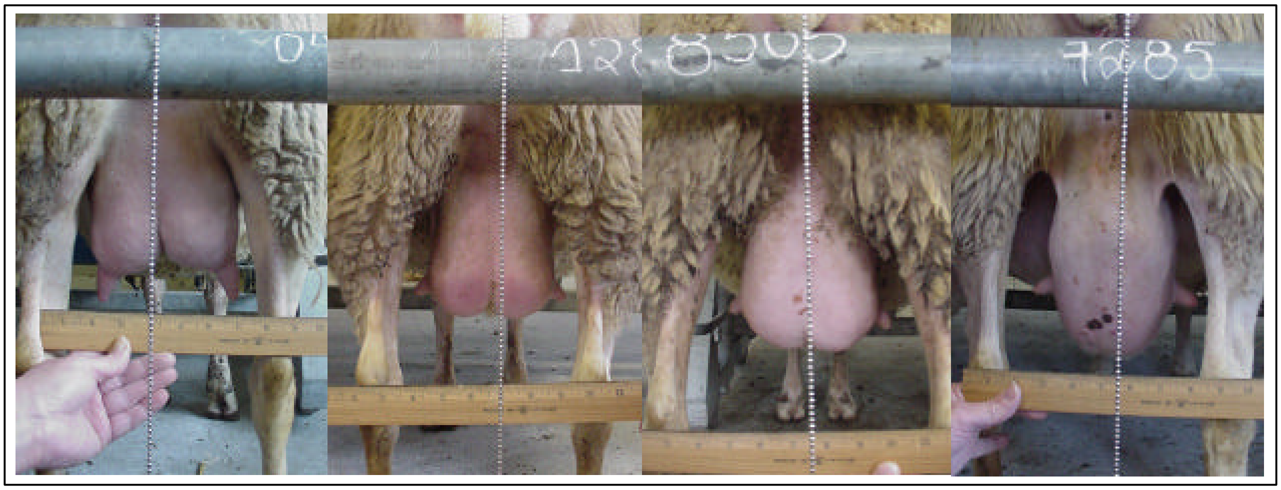
Udder shape, equivalent to a typology of expanded categories (nine), was highly repeatable and heritable, indicating its utility as a single trait for dairy sheep selection. Nevertheless udder shape showed high and positive genetic correlation with udder attachment (r= 0.55) and teat placement (r= 0.96), as a result of the main role of these traits in the definition of udder shape. Consequently, the use of the first four linear udder traits will be sufficient to improve programs of udder morphology. Phenotypic and genetic correlations showed that selection for milk yield will produce worse udder morphology, mainly in udder high and teat placement, giving as a result baggy udders which are inadequate for machine milking.

Repeatabilities of udder linear scores obtained in Lacaune dairy breed (Marie et al., 1999) were also high (r= 0.59 to 0.71) and show moderate phenotypic correlation with milk yield in primiparous and multiparous ewes. Heritabilities of udder traits reported in Assaf (h^2= 0.23 to 0.42; Gootwine et al., 1980), Chios (h^2= 0.50 to 0.83; Mavrogenis et al., 1988), and Sarda with the seven expanded typologies (h^2= 0.55; Carta et al., 1999), gave higher values but, as indicated by the last authors, probably they were overestimated. Nevertheless, taking into account the conclusions of Fernández et al. (1997), the genetic variability and heritability of the studied udder traits indicate that the efficiency of the breeding programs could be improved and some selection pressure on udder traits in long-term breeding programs needs to be considered.

Use of digital pictures to study udder morphology. Practical application of the digital system for evaluation of mammary morphology may provide an easy and accurate method to study ewe udders. Advantages of the digital picture method are that pictures can be taken faster than the *in vivo* measurements at the farm, analyzed at our convenience, and it can provide a permanent record for future use.

To evaluate the effectiveness of this method the relationship between udder traits measured *in vivo* and from digital photographs were studied on 120 U.S. dairy-cross ewes from a University farm (Rovai et al., 2003). Digital pictures were taken in the milking parlor of the rear udder of each ewe at the time of the *in vivo* measurements (objective measurements and linear score system). A ruler, at each picture taken, was held parallel to the ground in the same vertical plane as the back of the udder and a few cm below the bottom of the udder to serve as a calibration device for measurements on the digital pictures (Figure 6). Likewise a plumb bob was suspended vertically in back and in the middle of the udder while taking each picture to give a true vertical line as a reference for measuring teat angle. Measurements from the digital pictures were obtained using the public domain software, Image Tool from Texas University, available on the Internet.

Figure 6. Examples of udder digital pictures.



Comparisons of the in vivo and digital measurements are presented in Table 7. In general, udder traits *in vivo* did differ neither statically nor substantially from the digital pictures measurements. Teat length was the only trait that differed between methods; perhaps due to folding at the teat udder junction, which is not visible in the measurements taken from the pictures.

Table 7 **.**Udder measurements taken *in vivo* and from digital pictures.

Traits		Measurements	
		in vivo	picture
Udder measurements			
Udder depth	cm	21.8	19.3
Udder width	cm	13.9	12.9
Teat length	cm	3.3[a]	2.2 [b]
Teat angle	degrees	52.6	52.8
Udder linear score			
Udder depth	1-9	5.4	5.3
Udder shape	1-9	3.6	3.6
Teat length	1-9	5.3	5.6
Teat angle	1-9	3.9	3.8

All digital measurements were significantly correlated with those measured in vivo. Phenotypic correlations between the methods (direct udder measurements and linear udder score) were: 0.73 for udder height, 0.67 for udder width, 0.47 for teat length, 0.88 for teat angle, 0.68 for teat size score, 0.79 for teat angle score, 0.88 for udder height score, and 0.89 for udder shape score. The major ewe udder traits that can be viewed from the rear can be accurately measured from digital photographs of the rear udder.

***Ultrasonography and milk production capacity*:** Size of the cisterns is related to morphology and yielding capacity of the udder, varying markedly with time from last miking. Apparently, short-term autocrine inhibition of milk secretion in the mammary gland has been related to cisternal size, the large-cisterned animals being in general more efficient producers of milk and more tolerant to long milking intervals and simplified milking routines (Wilde et al., 1996). Machine milkability can be modified by cistern features, however, there is a low relationship founded between cistern size and milk yield (Gallego et al., 1983; Labussière et al., 1981; Fernandez et al., 1995), due probably to the method used on its valuation. Cistern is a non visible internal udder structure, and its size together with all other udder traits have been measured externally using a ruler and protractor. Recent literatures described the use of ultrasound technique for estimating the size of udder cisterns.

Ultrasonography has been used as a non invasive method to study the internal structure of the mammary gland in cows (Bruckmaier and Blum, 1992; Bruckmaier et al., 1994; Ayadi et al., 2003a), sheep (Caja et al., 1999; Nuda et al., 2000; Rovai et al., 2000; Rovai et al., 2003) and goats (Salama et al., 2004) and to measure the milk storage capacity within the udder (Ayadi et al., 2004; Caja et al., 2004). The principle structures of the mammary gland, as cistern area and teat cistern, can easily be determined by the position and frequency of the transducer used for its exploration. In dairy sheep, a specific method for mammography was proposed by Ruberte et al. (1994a), being the transducer applied directed from the portion of the proximal intermammary groove, between localizations areas of superficial inguinal lymph nodes, towards the teat. The method can also be used to estimate the distribution and movements of milk between the udder compartments and for non invasive dynamic studies on cisternal milk.

Differences in cisternal area according to dairy species and dairy sheep breed are summarized in Figure 7.

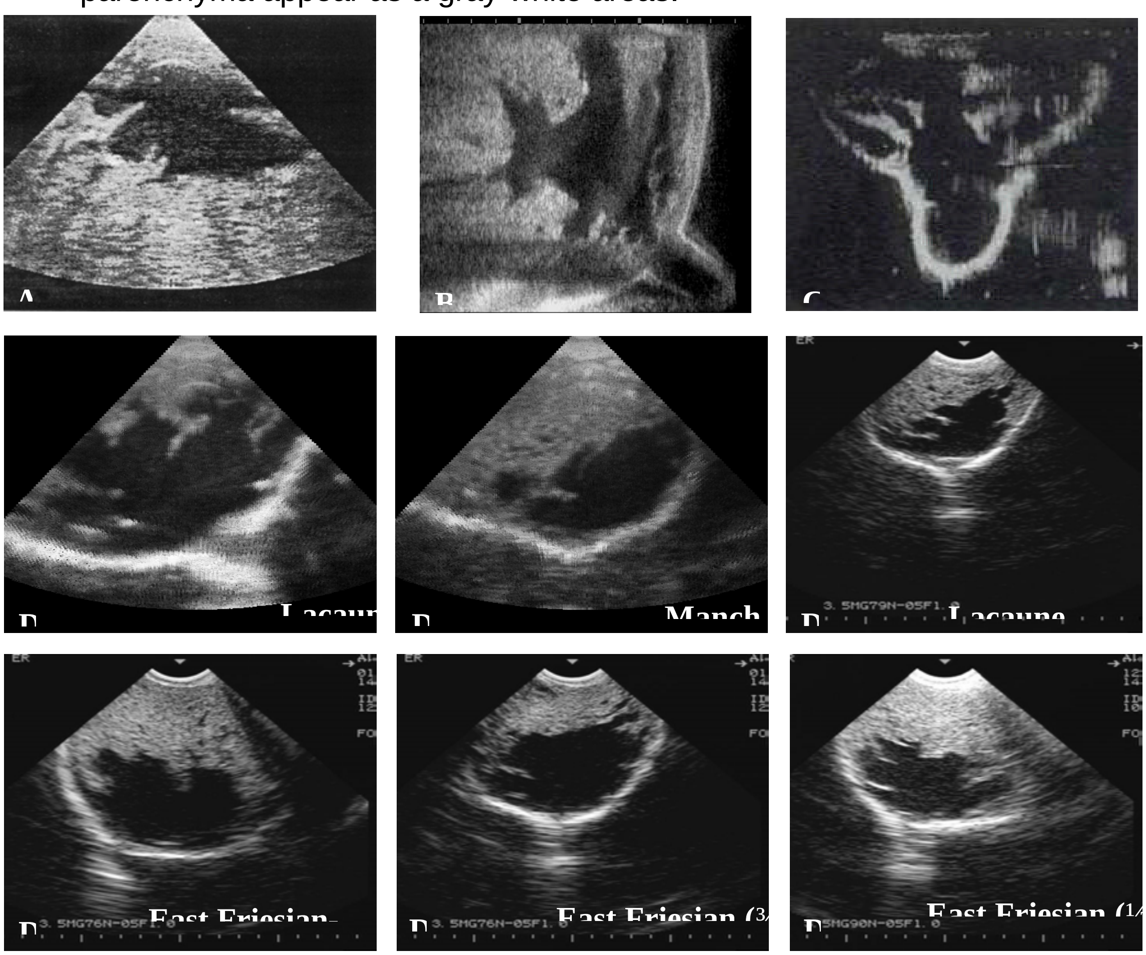
The differences in cistern capacity according to the productive level of two different dairy breeds were evaluated by Rovai et al. (2002). In this study, Lacaune ewes showed a larger area of the mammary cistern and also a larger amount of cisternal milk when compared to Manchega ewes (24cm^2 and 275ml vs. 14cm^2 and 149ml, respectively). Lactation number did not affect cisternal area. However, this area, as well as the amount of stored milk, decreased through the lactation in both breeds.

The interbreed differences on cistern storage capacity was also studied among dairy-meat cross ewes under U.S. production conditions (Rovai et al., 2003). Cistern area was different between ewe crosses as shown in Table 8. East Friesian (¾ crosses) and East Friesian-Lacaune dairy ewes had greater cistern area than ewes of the other two breeds (East Friesian, ½ crosses; Lacaune ewes). Cistern area and as well as milk yield in this study, decreased through lactation and increased with parity.

In general, cisternal areas and cisternal milk shows high dependency. The correlation coefficient was reported between cisternal areas and cisternal milk, and also with milk production, udder size measurements, and, in a lower extent, with teat measurements.

The observed better milkability of Lacaune ewes can be explained by the progress in breeding for improving milk production which also provided animals with quiet temperament at the milking parlor, more spontaneous milk ejection reflex and improvement of the dairy sheep management without the need of a previous udder preparation as used for dairy cows.

Figure 7. Cistern ultrasound scans in dairy cows (**A,** Ayadi, 2000; **B**, Rovai et al. 2004), dairy goats (**C**; Bruckmaier y Blum, 1992), and different breeds of dairy ewe (**D**). Udder cisterns filled with milk appear as dark areas, and the glandular parenchyma appear as a gray-white areas.



The use of cistern ultrasonography in dairy cows showed that losses in total milk yield is negatively related with cisternal milk volume (r=-0.77) and cisternal size (r=-0.70), meaning smaller losses in big udders in response to omitting one milking weekly (Ayadi et al., 2003). Recent studies also suggest that udder anatomy (mainly size of mammary cisterns) in terms of to milk storage may be an important factor in determining reduced yield associated with extended milking intervals in dairy species (Knight and Debwhurst, 1994; Stelwagen et al., 1996; Davis et al., 1998; Ayadi et al., 2003; Salama et al., 2003). Regarding this subject, the omission of one or more milkings per week in dairy ewes as shown in dairy goats (p.e. Sunday afternoon) would provide an important improvement in the quality of life of farmers, especially in small or family based dairy farms.

Table 8. Cistern area by ultrasonography, average milk production, and relation between scan area and cistern milk according to dairy species and the ultrasound scanner used (AMP, average milk production; Area, cistern area).

Dairy species	AMP	Area (cm^2)	Cistern milk×Area	Array scanner (MHz)		Authors
Dairy cows						
Simmental×Red Holstein	26 kg/d	28	-	5.0	linear	Bruckmaier et al., 1992[1]
Holstein	20 l/d	3-41	0.84-0.88	5.0	sectorial	Ayadi et al., 2003
Buffalo						
Murrah	50-320[2]	26-70	0.87	6.0	linear	Thomas et al., 2004
Dairy goats						
Swiss Saanen	3.5 kg/d	16	-	5.0	linear	Bruckmaier et al., 1992[1]
Murciano-granadina	1.12 l/d	13-28	0.72	5.0	sectorial	Salama et al., 2004
Dairy sheep						
East Friesian	3.2 kg/d	19	-	5.0	linear	Bruckmaier et al., 1992[1]
East Friesian crossbred						
EF (½ EF)	1.2 l/d	27	0.71	3.5	sectorial	Rovai et al.[4]
EE (¾ EF)	1.3 l/d	30	0.76	3.5	sectorial	Rovai et al.[4]
EF-LC (¼EF-½LC)	1.6 l/d	32	0.73	3.5	sectorial	Rovai et al.[4]
Lacaune crossbred						
LC (½ LC)	1.2 l/d	24	0.64	3.5	sectorial	Rovai et al.[4]
Lacaune	1.7 l/d	24	0.50[3]	5.0	sectorial	Rovai et al., 2001
Manchega	0.9 l/d	13	0.82	5.0	sectorial	Rovai et al., 2001
Sarda	92 to 156[2]	19	0.82	3.5	linear	Nudda et al., 2000
Meat Sheep	1.62 l/d	5.6	0.90	5.0	sectorial	Caja et al., 1999

[1] Five animals from each group to study the effect of exogenous oxytocin on gland and teat cistern. Values shown correspond to the gland cistern before oxytocin treatment.
[2] These values correspond to the cisternal yield (ml).
[3] The lower value of correlation for Lacaune ewes can be probably explained by the capacity limitations of visualization using a 5MHz ultrasound transducer.
[4] Unpublished data.

Machine milkability in the dairy ewe

Milk fractions collected during milking, residual milk (e.g., obtained after oxytocin injection) and milk flow curves during machine milking have been used to evaluate machine milkability in dairy sheep (Labussière, 1988; Bruckmaier et al., 1997a; Marie-Etancelin et al., 2002; Rovai et al., 2002; Díaz et al., 2004). The methodology proposed in the M4 FAO Project (Labussière, 1983) is normally used as the standardized method for both criteria.

***Milk partitioning in the udder*:** Milk partitioning between cisternal and alveolar compartments may influence milk secretion and milk yield response to altered milking frequencies (Knight et al., 1994b; Ayadi et al., 2003a; Salama et al., 2004). Large differences between species and breeds exist with regard to the proportion of total milk that can be stored within the cisternal compartment (Bruckmaier et al., 1992; Ayadi et al., 2003a; Salama et al., 2004). In sheep, high variation in cisternal milk has been reported with values ranging from less than 30% for meat breeds (Caja et al., 1999) to more than 50% for dairy breeds (Nuda et al., 2000; Rovai et al., 2000; McKusick et al., 2002), showing that selection for milk yield resulted in larger cisternal udders to accommodate the greater milk volumes.

Nevertheless cisternal milk volume can be increased in some breeds by spontaneous liberation of endogenous oxytocin as a consequence of milking conditioned behavior or during udder manipulation. This can be avoided by using oxytocin antagonists to temporarily block spontaneous milk letdown, as reported in cows (Bruckmaier et al, 1997a; Wellnitz et al., 1999; Ayadi et al, 2003b), ewes (Rovai et al., 2000; McKusick et al., 2002) and goats (Knight et al., 1994; Salama et al., 2004).

Milk partitioning between the udder compartments (cisternal and alveolar) was determined in two different dairy sheep breeds, under the same production system, by Rovai et al. (2000) using an oxytocin receptors blocking agent as shown in Table 9.

Table 9. Milk partitioning in the udder of dairy ewes according to the breed and the use of Atosiban as an oxytocin blocking agent (Rovai et al., 2000).

Item	Manchega		Lacaune		SEM	Effect (*P* <)	
	Control	Atosiban[2]	Control	Atosiban		Breed	Atosiban
Milk yield[1], L/d	0.94	-	2.07	-	0.10	0.001	-
Milk composition[1]							
SCC, log_{10}/ml	5.07	-	5.22	-	0.31	0.632	-
Milk partitioning							
Cisternal, ml	122	118	299	239	79	0.001	0.001
Alveolar, ml	86	104	89	115	0.63	0.712	0.001
Total, ml	208	222	388	354	1.06	0.010	0.465
Cisternal: Alveolar (%)	59:41	53:47	77:23	68:32	-	0.001	0.001
Cisternal area, cm^2	12.4	13.1	24.0	23.2	0.90	0.001	0.961

[1] Average udder milk yield and composition during the experimental period (90 DIM).
[2] Oxytocin receptors blocking agent injected in jugular

As shown in Table 9, despite the differences in milk production (over 100%) at the same stage of lactation, alveolar milk was very similar in the two breeds, the difference being only 10% greater in Lacaune ewe. On the contrary, the difference in true cisternal milk was 102% greater according to the difference observed in yield. These differences suggest that the volume of cisternal milk is the only difference between Lacaune and Manchega breed and highlight the important role that cistern size plays in the milk yield of the dairy sheep.

Similarly, percentage milk fractions differed significantly according to breed, with superiority of cisternal fraction in Lacaune ewes, and consequently a greater percentage of alveolar milk in Manchega ewes. These results clearly support the interbreed changes due to selection programs schemes increasing the milk yield and consequently cisternal area of selected dairy sheep.

Carretero et al. (1999) studying the ultrastructure of the mammary gland in Manchega and Lacaune ewes reported the same mammary structures and pattern of development during lactation, describing an equally and extensive proliferation of the canicular system with a large number of alveolar sprouts between week 1 (suckling) and 5 (start of milking) in both breeds.

The use of an oxytocin receptors blocking agent is potentially a convenient method to determine with exactitude the amounts of cisternal and alveolar milk fractions, under normal conditions of milking (Knight et al., 1994). However, as observed in Table 9, the volume of milk fractions according to treatment tended to be different between breeds. The fractions were similar and accurate for Manchega ewes while the Lacaune presented a spontaneous milk ejection when entering to the milking parlor. These results suggest the necessity to use an oxytocin antagonist when we need to prevent the milk ejection and study the fractions of milk separately in well know adapted machine milking breed.

Machine milking ability

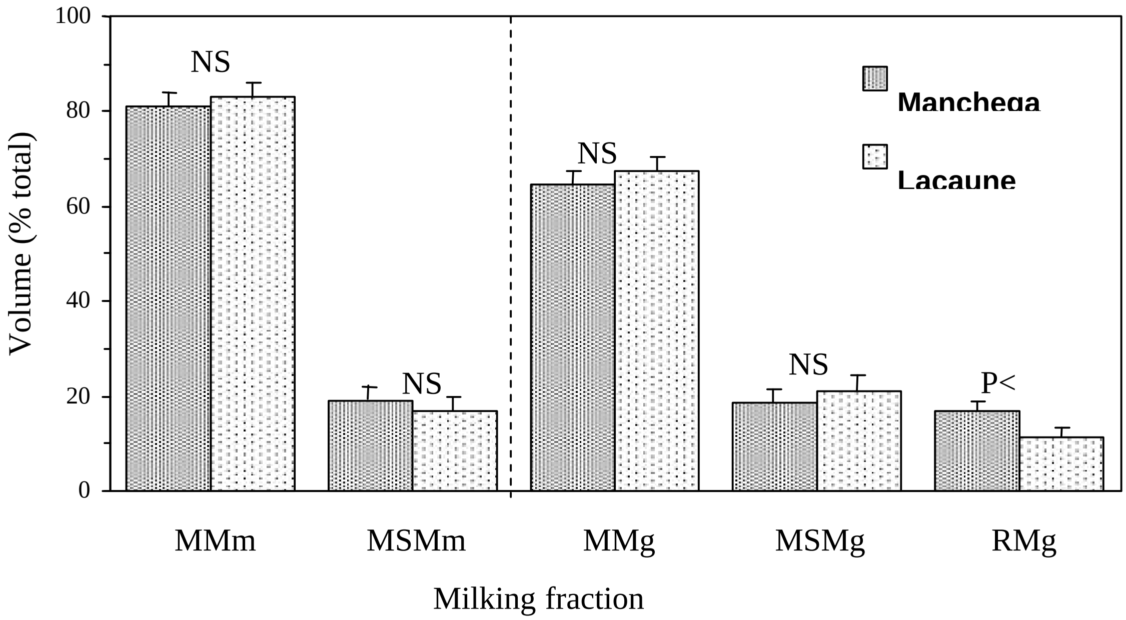
Machine milkability is normally estimated by fractional milking (i.e. machine milking, machine stripping, and extraction of residual milk after an oxytocin injection) or by analysis of milk emission curves obtained during machine milking without massage or extra stimulation of the mammary gland. The methodology proposed in the M4 FAO Project (Labussière, 1983) is normally used as the standardized method for both criteria.

***Milk fractioning*:** Milk fractions were mainly used as an important indicator for the evaluation of the milkability in dairy sheep when the routines included hand stripping as in the M4 FAO project (Labussière, 1983). Reported values of milk fractioning varied according to breed (Labussière, 1988; Such et al., 1999a), milking routine (Molina et al., 1989) and machine milking parameters (Fernández et al., 1999). Values of fractioning ranged normally from 60 to 75 : 10 to 20 : 10 to 15, for machine milking : machine stripping : residual milk, respectively.

The comparison of milking ability of two groups of ewes characterized by different milk yield (Manchega, 0.6 l/d; Lacaune, 1.3 l/d), was carried out by Such et al. (1999a) in late lactation (week 16) and under the same milking conditions. Values of fractional milking (machine milk : machine stripping milk : residual milk) were 65:19:16 and 68:21:11, for Manchega and Lacaune ewes, respectively. No significant differences were observed according to breed in percentages of milk fractions, except in the case of residual milk (Figure 8). Both breeds gave on average 86% milk during machine milking, but Manchega breed retained more milk in the ductal system of the udder. This result was obtained despite the differences reported in milk yield and in absolute values of each fraction, as well as in cistern size and udder morphology, of each breed as discussed previously. Differences in udder size and morphology explain the increase in machine stripping milk according to milk yield, and were also reported by effect of lactation stage (Gallego et al., 1983b; Labussière, 1988).

As a conclusion, the obtained results show the unsuitability of the milk fractions as a main indicator for the evaluation of milkability in ewes, fractioning probably being a better indicator for the study of machine or milking routine effects, which were the same in this case. Moreover, Caja et al. (1999a) in goat and Fernández et al. (1999a) in sheep, reported significant differences in the machine stripping fraction according to milking routine or machine milking parameters, respectively.

Figure 8. Milk fractioning obtained during machine milking of dairy sheep according to the breed at the same stage of lactation (Such et al., 1999a): MM, machine milk; MSM, machine stripping milk; RM, residual milk; m, milked; g, present in the gland.



***Milk emission*:** Milk emission is one of the most interesting criteria for studying milkability in the machine milking of dairy sheep and its main traits are considered to be relevant for the design of milking machines and to adopt the optimal milking routine in each breed. As milk yield strongly influences intramammary pressure, a strong effect of milk production on all milk flow parameters is also expected, as indicated by Marnet et al. (1999) and observed clearly in dairy goats (Bruckmaier et al., 1994; Caja et al., 1999a). Moreover, milk emission will be different for a.m. and p.m. milkings, and its curves should be analyzed separately. Morning milking will increase milk flow and milking time, but emission of alveolar milk will be observed easily and separately in the afternoon.

Milk emission curves are obtained by manual (Labussière, 1983; Fernández et al., 1989b; Peris et al., 1996) or automatic methods (Labussière and Martinet, 1964; Mayer et al., 1989b; Bruckmaier et al., 1992; Marie et al., 1999). The flow from the right and left mammary glands can be recorded separately (Labussière and Martinet, 1964; Labussière, 1983) or as a whole (Fernández et al., 1989b; Peris et al., 1996; Bruckmaier et al., 1992; 1996; Marie et al., 1999; Marnet et al., 1999), but results and conclusions of flow may be different in consequence (Rovai, 2000).

A good milk emission curve should mean a quick and complete milking, with a high milk flow rate and an effective ejection of alveolar milk under the action of the oxytocin. The milk emission pattern is related to the structure of the udder (cistern size), to the teat traits (size and position) and to the neuro-hormonal behavior of the ewe (Labussière et al., 1969; Bruckmaier et al., 1994, 1997; Marnet et al., 1998, 1999).

Globose and big cisterned udders with medium size, vertical and sensitive teats, that is able to open the sphincter rapidly and widely at low vacuums, is preferable.

An early typology of milk emission curves was proposed by Labussière and Martinet (1964), and widely adopted for the study of sheep dairy breeds (Labussière, 1983, 1988). The milk emission typology considers curves of different shape: '1 peak' (single), '2 peaks' (bimodal) and others, the last corresponding to animals with irregular or multiple milk emission curves (≥ 3 peaks). In some cases an ewe changes the milk emission typology on consecutive days, and more than two recordings are recommended in practice. The first peak occurs very early after cluster attachment and it is identified as cisternal milk, which is drained after the opening of the teat sphincter. The second peak corresponds to alveolar milk and occurs as a consequence of liberation of alveolar milk during the appearance of the milk ejection reflex by effect of released oxytocin (Labussière and Martinet, 1964; Labussière et al., 1969; Fernández et al., 1989b; Marnet et al., 1998). Milking-related release of oxytocin has been measured in dairy sheep by Mayer et al. (1989a) and Marnet et al. (1998). The machine milk fraction is normally greater and milk flow maintained high during a longer time in the bimodal ewes, which are considered favorable for machine milking in dairy ewes. Milking of ewes showing an single milk emission curve can be completed by using a milking routine with machine or manual stripping ('repasse') after cessation of the machine milk flow, which is unfavorable and increases dramatically the total milking time per ewe. Moreover, simplified milking routines (without hand or machine stripping) are well accepted by bimodal ewes as indicated by Molina et al. (1989) in Manchega dairy sheep.

Distribution of animals in a flock according to number of peaks has also been used as an index of machine milkability in dairy breed as indicated by Labussière (1988). Sheep breeds with a greater percentage of ewes showing 2 peaks being the most appropriate for machine milking. Nevertheless peak distribution in a flock changes according to the stage of lactation as observed by Rovai (2000) in a flock with breeds of different yield and milkability (Table 10). Number of ewes in the 1 peak typology increased at the end of lactation and on the contrary the ≥ 3 peaks decreased compensating the losses in the 2 peaks group.

Table 10. Distribution (%) of milk emission curves obtained in dairy ewes during machine milking according to breed and stage of lactation in (Rovai, 2000).

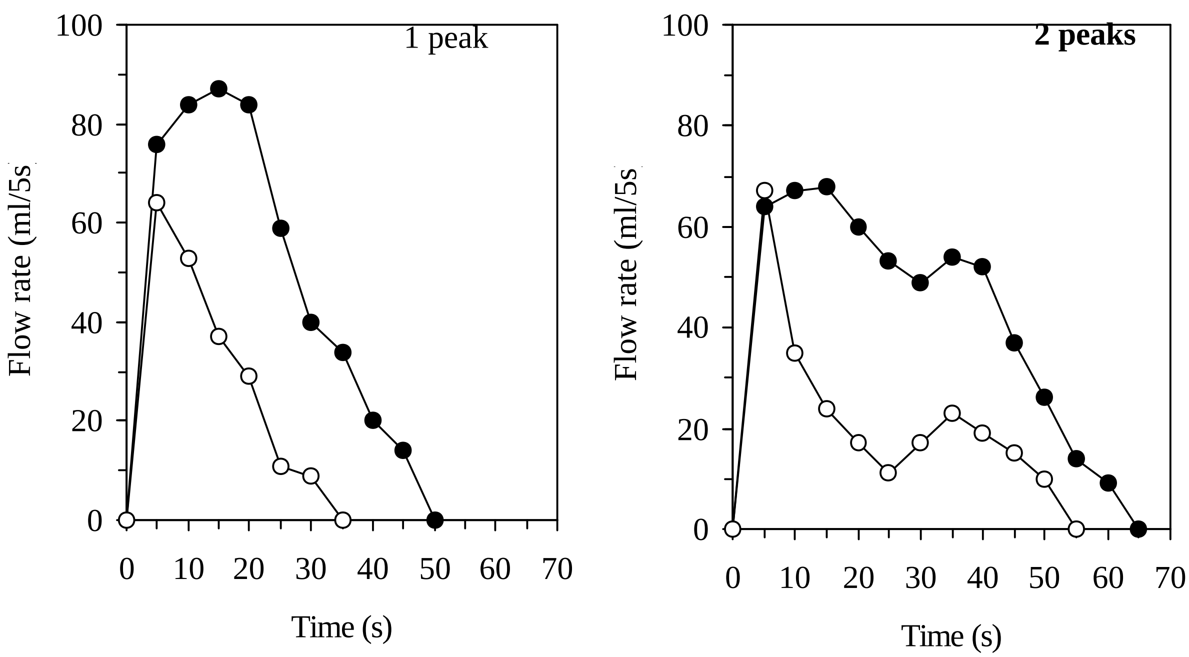
Stage of lactation (d)	Manchega			Lacaune		
	1 peak	2 peaks	≥ 3 peaks	1 peak	2 peaks	≥ 3 peaks
42[1]	28.6	56.7	14.7	8.0	57.2	34.8
	(62)[2]	(123)	(32)	(16)	(115)	(70)
70	29.6	64.2	6.19	9.8	49.4	40.8
	(67)	(145)	(14)	(25)	(126)	(104)
98	39.4	54.8	5.9	18.0	55.6	26.5
	(74)	(103)	(11)	(34)	(105)	(50)

[1]: First week after weaning at day 35.
[2]: Number of emission curves analyzed.

Machine milking parameters can also modify the milk flow characteristics in dairy sheep, mainly the volume of the second peak and the milking time, as reported by Fernández et al. (1999) in Manchega dairy ewes milked at different vacuum levels (36 and 42 kPa) and pulsation rates (120 and 180 P/min) .

Clear differences in milk emission curves during the p.m. milking were observed by Such et al. (1999b) according to breed, when Manchega and Lacaune dairy ewes at the same stage of lactation were compared (Figure 9) indicating the importance of this criterion on the evaluation of milkability. Daily milk yield at comparison and percentage of bimodal ewes during the comparison period were 0.6 l/d and 38%, and 1.3 l/d and 83%, for Manchega and Lacaune ewes respectively.

Figure 9. *Milk emission curves resulting from p.m. machine milking of dairy sheep according to breed (?, Manchega; ?, Lacaune) and number of peaks (Such et l., 1999b).*



Significant differences in the values of maximum milk flow (76 *vs* 129 ml/5s) and milk peak volume (207 *vs* 586 ml) were observed for the 1 peak Manchega *versus* Lacaune ewes, respectively. The significant values for the 2 peaks ewes were: first peak (72 *vs* 94 ml/s; and, 171 *vs* 344 ml) and second peak (41 *vs* 83 ml/s; and, 78 *vs* 239 ml), for Manchega *vs* Lacaune, respectively. Total emission time until a milk flow <10ml/s were: 1 peak (25 *vs* 39 s) and 2 peaks (48 *vs* 56 s) for Manchega *vs* Lacaune respectively, being the difference significant in all cases. Observed differences in milk flow parameters between breeds were in accordance with their milk yield. Nevertheless, despite the differences of milk emission curves, the total volume of milk obtained in 1 peak *vs* 2 peaks ewes were similar in each breed: Manchega (207 vs 249 ml) and Lacaune (586 vs 583 ml) respectively for 1 *vs* 2 peaks. Moreover maximum milk flow was the same in both breeds for the 2 peaks ewes, despite the differences in yield. As a consequence, it can be suggested that other factors different from milk ejection reflex are mainly conditioning the milk flow during machine milking in dairy ewes.

At present teat and cistern characteristics seem to be the most important factors in relation to milk flow curves in dairy sheep. Results of Marie et al. (1999) and Marnet et al. (1999) in Lacaune dairy sheep, and Bruckmaier et al. (1994, 1997) studying the effects of milking with or without prestimulation in Saanen dairy goat, and Friesian and Lacaune dairy sheep, are in accordance with these conclusions.

Marnet et al. (1999) indicate that lag time between teat cup attachment and arrival of the first milk jets to the recording jar can be used as an indicator of milkability. Moreover significant correlation of lag time with vacuum needed to open the teat sphincter (r= 0.61), total milking time (r= 0.86), and mean (r= –0.84) and maximum (r= –0.80) milk flow rates, were observed. A low but significant correlation between Somatic Cell Count and maximum milk flow was also obtained (r= 0.39). Moreover, the vacuum value needed to open the teat sphincter seems to remain constant in each animal during lactation and is also positively related with the teat congestion observed after milking. The highest vacuum value needed to open the teat sphincter in this experiment was 36 kPa, suggesting that the use of a low milking vacuum is possible in Lacaune dairy ewes.

According with these results Marie et al. (1999) studied the main udder traits and milk flow characteristics by using an automatic milk recorder in two lines of Lacaune dairy ewes differing 60 l in genetic merit. Milk yield and milking time averaged 0.94 l/d and 2 min 44 s respectively. Average lag time was 25 s for a minimum volume of milk of 160 ml. Maximum milk flow (0.87 l/min) was observed 27 s later (52 s from cluster attachment) in average. Lag time was negatively correlated with milk yield (r= –0.26) and maximum milk flow (r= –0.49). Measured repeatabilites for milk yield, lag time and maximum milk flow were high in the same lactation (r= 0.46 to 0.59) and between lactations (r= 0.40 to 0.75). Flow parameters varied according to milk yield as previously reported by Bruckmaier et al. (1994) in goats, but the increase in milking time was lower than in milk.

Correlation of udder traits with flow parameters obtained by Marie et al. (1999) were low (–0.3 to 0.3) and tended to increase in multiparous ewes. An increase in teat angle was associated to a greater lag time (r= 0.28) and a lower maximum milk flow (r= –0.26), both unfavorable traits. On the contrary, a very marked intermammary groove was correlated to greater milk yield (r= 0.28) and milk flows (r= 0.33 to 0.34), and lower lag time (r= –0.23). As a final conclusion the authors indicate that a good udder shape tends to improve milkability in dairy sheep and recommended the inclusion of this trait in genetic programs.

Bruckmaier et al. (1997) compared milk flow and udder anatomy, including ultrasound images, in Lacaune and Friesian dairy ewes. Both breeds showed similar milk yield and cisternal areas. Nevertheless, milk flow was lower and stripping milk yield higher in the Friesian ewes as a consequence of udder morphology that showed cisternal bags below the level of the teat channel. The use of a prestimulation routine failed to reduce stripping milk and total milking time but increased milk flow in both breeds. Oxytocin release was different in both breeds and a dramatic increase in blood concentration was observed in Lacaune ewes during teat stimulation and early milking, while only slight release was found in Friesian ewes. During machine milking significant increase in oxytocin was observed in 88% of Lacaune but only in 58% of Friesian ewes. The authors also indicate the occurrence of single peak typologies in milk emission with or without increasing concentrations of oxytocin in both breeds.

Rovai et al. (2003) studying the milking emission parameters recorded during machine milking in U.S. dairy-cross ewes (Table 10).

Table 10. Milking characteristics in U.S. dairy-cross ewes (Rovai et al., 2003).

Trait	Ewes crosses							
	EE (¾ EF)	*SEM*	**EF** (½ EF)	*SEM*	**LC** (½ LC)	*SEM*	**EF-LC** (¼EF-½LC)	*SEM*
n								
Milk yield, L	1.25 [a]	0.06	1.24 [a]	0.05	1.20 [a]	0.06	1.59 [b]	0.08
Lag time, s	2.16	0.19	2.24	0.15	2.12	0.20	2.25	0.24
Volume 1st minute, L	0.46	0.03	0.49	0.02	0.47	0.03	0.56	0.04
Volume without stripping, L	0.63 [a]	0.03	0.62 [a]	0.03	0.63 [a]	0.04	0.87 [b]	0.04
Total volume total, L	0.78 [a]	0.29	0.77 [a]	0.24	0.78 [a]	0.32	1.06 [b]	0.38
Time without stripping, s	1.26 [a]	0.09	1.21 [a]	0.07	1.31 [a]	0.09	1.61 [b]	0.11
Total time, s	1.63 [a]	0.12	1.61 [a]	0.09	1.75 [a]	0.13	2.13 [b]	0.15
Average flow rate, L	0.45	0.02	0.42	0.02	0.44	0.02	0.48	0.03

Milk yield volume was highest in East Friesian-Lacaune ewes according to their high milk production. Total milking time was also greatest in East Friesian-Lacaune ewes, increasing with parity, and decreasing during lactation. Volume at the first minute of milking was similar for U.S dairy-cross ewes regardless of different blood percentages. The volume of milk during the first minute of milking can assure the presence of alveolar milk ejection and milkability of these crossbred ewes. Bruckmaier et al. (1997) reported that milk flow curves with diffuse shape and peak flow rate below 0.4 kg/min represent extremely weak or totally absent oxytocin release.

Positive relations was observed between milking kinetics and udder traits (r = 0.15 to 0.38, and also between milk volume during the 1st minute and cisternal area (r = 0.34).

Summary and implications

Information collected during this paper show that to improve milkability, a well shaped and healthy udder of dairy sheep should have:

- Great volume and globosely shaped
- Teats of medium size (length and width), implanted near to vertical
- Soft and elastic tissues, with palpable gland cisterns inside
- Moderate height, no surpassing the hock
- Marked intermammary ligament

Relationship between morphological and productive traits is evident in dairy sheep as a consequence of anatomical and physiological characteristics. Phenotypic and genetic correlations indicate that selection for milk yield will produce worse udder morphology, mainly in udder height and teat placement, causing baggy udders which are inadequate for machine milking. Teat and cistern characteristics appear to be the most limiting factors in machine milkability and especially in milk flow. Genetic variability, repeatability and heritability of udder traits indicate that some selection pressure on udder traits needs to be considered. In practice the use of four linear udder traits will be sufficient to improve udder morphology in long-term breeding programs.

Breed differences are also detected despite the differences in milk yield, and values of milk partitioning are in accordance with the known milkability of each dairy sheep breed, the most productive ewes showing a larger machine milk fraction. The differences in cisternal fraction of milk reported on different dairy sheep breeds explain the different mammary gland anatomy and morphology among breeds and also selected ewes.

Mammary ultrasonography is an efficient method to evaluate the size and the productive capacity of the ovine udder (highly correlated with milk production). This method seems to indicate that cisternal size is a direct limiting factor for milk secretion in dairy sheep and its importance is greater than the amount of secretory tissue in the current situation.

Preliminar results on U.S. dairy-cross ewes shows a superior milk production of East Friesian-Lacaune ewes may be related to more cisternal milk storage area. The Lacaune breed resulted in poorer udder confirmation (larger teat angle, greater external cisterns).

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COMPARISON OF EAST FRIESIAN AND LACAUNE BREEDS FOR DAIRY SHEEP PRODUCTION IN NORTH AMERICA

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Summary

A study was initiated in the autumn of 1998 to compare the East Friesian (EF) and Lacaune (LA) breeds for performance in a dairy sheep production system typical of the upper Midwestern U.S. Matings were designed to produce breed groups of high percentage EF, high percentage LA, and various EF-LA crosses. This paper summarizes data collected through the summer of 2004. Based on these results, replacement of 50% EF breeding with 50% LA breeding will decrease lambs born per 100 ewes exposed by about 15, may result in a slight decrease in milk production (~7%), and will raise fat and protein content of milk by .3 to .6 percentage units. A two-breed rotational crossbreeding program with East Friesian and F1 East Friesian x Lacaune rams is proposed. This system will result in a flock in which about half of the ewes are 83%EF,17%LA and the other half are 67%EF,33%LA.

Background

The raising of sheep for milk is a new enterprise to North American agriculture (Thomas, 2004). Sheep in North America have been selected for meat and wool production. Therefore, one of the first major constraints to profitable sheep dairying was the low milk production of domestic breeds.

The East Friesian (EF) is a very high milk-producing breed with an origin in northern Germany (Alfa-Laval, 1984). The first importations of EF genetics into North America for the specific purpose of dairy sheep production were by Hani Gasser, British Columbia, Canada (semen in 1992) and Chris Buschbeck and Axel Meister, Ontario, Canada (embryos). The first crossbred EF rams were imported into the U.S. in 1993 from Hani Gasser by the University of Minnesota, the University of Wisconsin-Madison (UW-Madison), and Hal Koller, a dairy sheep producer in Wisconsin.

The EF cross ewes produced from these crossbred rams produced almost twice as much milk per lactation as domestic breed crosses (Dorset-crosses) under experimental conditions at the UW-Madison (Thomas et al., 1998, 1999, 2000). Continued experimentation with EF crosses at UW-Madison and their performance in commercial dairy flocks in the U.S. and Canada further showed their superiority for milk production, and most commercial operations moved quickly to crossbred, high percentage, or purebred EF ewes. The accelerated move to EF in North America was facilitated by further importations of semen, embryos, and live animals from Europe and New Zealand to both Canada and the U.S. after 1992.

A second dairy sheep breed, the Lacaune (LA) from France (Alfa-Laval, 1984), also is available in North America. Josef Regli imported Lacaune embryos to Canada from Switzerland in 1996 (Regli, 1999), and he remains the primary source of LA genetics in North America. The UW-Madison imported the first LA genetics into the U.S. in 1998; semen from three rams in the U.K. and two LA rams from Josef Regli. Subsequently, a few LA rams from the Regli flock were used by dairy sheep producers in Canada and the U.S., as well as some crossbred Lacaune rams from UW-Madison. Access of U.S. producers to LA genetics is now difficult due to the Canadian-U.S. border closure to movement of ruminants to the U.S. because of concerns about bovine spongiform encephalopathy (BSE), and the inability of either country to access additional LA genetics from Europe due to animal health import restrictions.

The LA is the most numerous sheep breed in France. It has been selected in France for increased milk production under a sophisticated selection program incorporating artificial insemination, milk recording, and progeny testing of sires for longer than any other dairy sheep breed in the world. Annual genetic improvement for milk yield in the French LA is estimated at 2.4% or 5.7 kg (Barillet, 1995).

British Milksheep also have been imported into North America, and they are a relatively popular breed in flocks in Ontario, Canada.

Materials and Methods

During the autumns of 1998 to 2003, Dorset-cross ewes at the Spooner Station and Polypay and Rambouillet ewes at the Arlington Station of UW-Madison were artificially inseminated or naturally mated to EF or LA rams. Lambs sired by 14 purebred EF rams and six purebred LA rams representing all (or at least the vast majority) of the lines of these two breeds in North America were produced. Lambs were fed high-concentrate rations in confinement. Male lambs and a few cull ewe lambs were marketed at approximately 125 pounds liveweight, and the vast majority of the ewe lambs were retained for breeding.

First-cross (F1) ewe lambs born and raised at both locations from 1999 through 2003 were mated at the Spooner Station in their first autumn at approximately 7 months of age, and they lambed for the first time at approximately one year of age the following spring. Generally, young F1 ewes and their descendants were mated to either EF or LA rams to producer higher percentage EF or LA offspring or various crosses of EF-LA breeding. Most older dairy-cross ewes were mated to Dorset, Hampshire, or Suffolk rams to produce terminal market lambs. Each year, all replacement ewe lambs were sired by EF or LA rams. Ewes were retained in the flock for at least two seasons unless culled for a debilitating condition. Lambs were raised on their dams or on milk replacer until 30 days of age. After weaning at 30 days of age, lambs were raised on high-concentrate diets in confinement.

This mating system ultimately will result in the production of ewes of a high percentage dairy breeding with some ewes containing only EF dairy breeding, some ewes only LA dairy breeding, and some ewes various combinations of both EF and LA breeding. Currently, large numbers of animals of 1/2 dairy breeding (1/2EF or 1/2LA) and 3/4 dairy breeding (3/4EF; 1/2EF,1/4LA; 1/2LA,1/4EF; or 3/4LA) have been evaluated. Smaller numbers of animals of 7/8 and higher dairy breeding have been evaluated, and they have been grouped into two groups depending upon if they contain more EF (7/8+(EF,LA)) or LA (7/8+(LA,EF)) breeding.

Dairy ewes were milked on one of three weaning/milking systems: DY30, DY1 or MIX. The DY30 system is as follows: ewes nurse their lambs for approximately 30 days, after which lambs are weaned onto dry diets, and ewes are milked twice per day until a test day on which their total daily milk yield is less than .25 kg. The DY1 system is as follows: lambs are weaned from ewes within 24 hours of birth and raised on milk replacer until weaned onto dry diets at approximately 30 days of age, and ewes are milked twice per day from 24 hours postpartum until a test day on which their total daily milk yield is less than .25 kg. The MIX system is as follows: for the first 30 days postpartum, lambs are separated from their dams overnight, ewes are milked once per day in the morning, and lambs are returned to their dams for the day; lambs are weaned onto dry diets at approximately 30 days of age, and after their lambs are weaned, ewes are milked twice per day until a test day on which their total daily milk yield is less than .25 kg. The DY30 system is used more often with ewe lambs in their first lactation than with older ewes. Among older ewes, the DY1 system is used more often than the MIX system.

The number of observations included in the analysis of each trait was as follows:

1. Birth weight – 1,794 lambs
2. 30-day weight – 1,469 lambs
3. 150-day weight (majority are male market lambs) – 651 lambs
4. Fertility – 942 exposures on 483 individual ewes
5. Number of lambs born/ewe lambing – 877 lambings
6. Lactation traits – 796 lactations on 402 individual ewes

Data were analyzed with the Mixed Procedure of the Statistical Analysis System (SAS). For lamb growth traits, models included the effects of dam breed group, sire breed, sex of lamb, birth type of lamb, dam age, and year of record as fixed effects and dam and sire as random effects. Models for reproductive traits included the effects of ewe breed group or sire breed of ewe, ewe age, and year of record as fixed effects and ewe and sire as random effects. Lactation models include the effects of ewe breed group or sire breed of ewe, weaning/milking system, ewe age, and year of record as fixed effects and ewe and sire as random effects.

Results and Discussion

Growth. Table 1 presents birth, 30-day, and 150-day weights for lambs born to ewes of different ages and dairy breed composition and sired by rams of different breeds. Lamb weights are given in English (pounds) units whereas the lactation traits presented later are given in metric (kilogram) units. While the U.S. is on the English system, some reliance on foreign information for dairy sheep has resulted in us thinking somewhat in the metric system when dealing with lactation production.

Table 1. Lamb growth traits (mean ± SE)

Item	Birth wt, lb.	30-day wt, lb.	150-day wt., lb.
<u>Dam age, yr</u>			
1	10.2±.3[c]	30.5±.6[b]	111.8±2.7[b]
2	11.3±.3[b]	31.4±.6[a]	118.4±2.8[a]
3+	12.2±.3[a]	32.2±.7[a]	113.0±3.3[ab]
<u>Dam breed group</u>			
Non-dairy	10.7±.4[a]	34.2±.9[a]	129.8±3.8[a]
1/2EF	11.1±.3[a]	31.7±.6[b]	120.1±2.9[b]
1/2LA	11.2±.3[a]	31.0±.6[bc]	113.0±3.0[c]
3/4EF	11.2±.4[a]	30.1±.8[c]	108.4±3.8[c]
1/2EF,1/4LA	11.7±.4[a]	31.1±.9[bc]	108.7±4.1[c]
1/2LA,1/4EF	11.3±.4[a]	32.1±.9[ab]	109.3±4.1[c]
3/4LA	11.1±.4[a]	30.9±.8[bc]	111.5±3.9[c]
7/8+(EF,LA)[e]	11.5±.4[a]	29.6±.9[c]	112.7±4.9[c]
7/8+(LA,EF)[f]	11.3±.5[a]	31.6±1.0[bc]	116.0±5.5[bc]
<u>Sire breed of lamb</u>			
EF	11.1±.2[a]	31.4±.5[abd]	106.4±2.5[c]
LA	10.2±.2[b]	29.2±.6[c]	107.6±2.6[bc]
Suffolk	11.7±.5[a]	33.7±1.2[a]	120.7±4.2[a]
Hampshire	11.6±.5[a]	30.9±1.3[abcd]	118.6±5.3[ab]
Dorset	11.5±.7[a]	31.6±1.5[abcd]	118.6±8.0[ab]

[a,b,c,d]Means within a column and within an underlined and bold item group with no superscripts in common are significantly different (*P* < .05).

[e]Dams are at least 7/8 dairy breeding with 3/4 or greater of EF breeding. A few ewes contain no LA breeding.

[f]Dams are at least 7/8 dairy breeding with 3/4 or greater of LA breeding. A few ewes contain no EF breeding.

First-lambing ewes produced lambs that were lighter ($P < .05$) at birth, 30 days, and 150 days than lambs produced by older ewes.

Dam breed group had no effect on birth weight. For both 30-day and 150-day weight, lambs born to non-dairy ewes had heavier ($P < .05$) weights than lambs born to dairy-cross ewes. The lambs born to non-dairy ewes were all raised on their dam and weaned at approximately 60 days of age, whereas the lambs born to the dairy-cross ewes were weaned onto dry diets at approximately 30 days of age, and many were raised artificially on milk replacer from shortly after birth. This difference in rearing systems may be the reason for these observed differences. Among lambs from dairy-cross ewes, there does not appear to be any consistent effect of the amount of dairy breeding in the dam or the EF or LA breeding composition of the dam.

Overall, Suffolk-, Hampshire-, and Dorset-sired lambs tended to have heavier weights than the EF- or LA-sired lambs. Between the dairy breeds, EF sires produced lambs with heavier ($P < .05$) birth and 30-day weights than did LA sires. Differences between the two dairy sire breeds for 150-day weight of their lambs were small and not statistically different.

These data suggest that the EF and LA breeds are slightly inferior to some common terminal sire breeds (Suffolk, Hampshire, Dorset) for growth rate. This is to be expected. A dairy sheep producer can take advantage of this fact by mating only the number of dairy ewes needed to produce replacement ewe lambs to dairy rams and mating the remainder of the ewes to terminal sires for market lamb production. The EF breed may be slightly superior to the LA breed for preweaning growth rate, and the LA breed may be slightly superior to the EF breed for post-weaning growth rate, but the differences are small. Growth rate is not an important consideration when dairy sheep producers decide between the EF and LA breeds.

Reproduction. Table 2 compares the reproductive performance of ewes of different ages, ewe breed groups, and sire breeds.

Percentage of ewes lambing of ewes exposed (fertility) was not significantly affected by any of the factors. Even though the differences are not significantly different, it is interesting to look at the fertility of the ewe breed groups within each percentage of dairy breeding subgroup. In each subgroup, the ewe breed group with the highest percentage of LA breeding had the lowest fertility (1/2 dairy breeding:1/2LA = 92.0%, 3/4 dairy breeding: 3/4LA = 91.2%, and 7/8 or greater dairy breeding: 7/8+(LA,EF) = 89.3%). Averaged over all ewe breed groups, ewes with a LA sire had a lower (not statistically significant) fertility (94.6%) than ewes with an EF sire (96.7%).

Litter size was different ($P < .05$) among ewes of the three age groups with older ewes giving birth to larger litters than younger ewes.

As with fertility, there are no significant differences among ewe breed groups within a percentage of dairy breeding subgroup for litter size. However, within each subgroup, an increase in LA breeding resulted in a decrease in litter size.

Averaged over all ewe breed groups, ewes sired by LA sires had smaller ($P < .05$) litter sizes than ewes sired by EF sires (1.69 vs. 1.85 lambs, respectively) (Table 2). When the number of lambs born per ewe exposed is calculated from the fertility and litter size values presented in Table 2, values for ewes sired by LA and EF sires are 1.60 and 1.79, respectively.

Differences between EF and LA breeds in reproduction should enter into a decision on which of these breeds to use. EF breeding can be expected to result in 10 to 20 more lambs born 100 ewes than LA breeding.

Table 2. Reproductive traits (mean ± SE)

Item	Fertility, %	Lambs born/ewe lambing, no.
Ewe age, yr		
1	94.3±1.5[a]	1.56±.04[c]
2	92.6±2.1[a]	1.65±.05[b]
3+	92.7±3.2[a]	1.89±.08[a]
Ewe Breed group		
1/2EF	95.4±2.6[a]	1.89±.06[a]
1/2LA	92.0±2.5[a]	1.79±.06[ab]
3/4EF	94.6±3.6[a]	1.82±.09[ab]
1/2EF,1/4LA	91.3±3.9[a]	1.67±.09[b]
1/2LA,1/4EF	96.0±4.0[a]	1.63±.09[b]
3/4LA	91.2±3.4[a]	1.50±.08[b]
7/8+(EF,LA)[e]	95.7±3.9[a]	1.66±.09[b]
7/8+(LA,EF)[f]	89.3±4.3[a]	1.64±.10[b]
Sire breed of ewe		
EF	96.7±1.4[a]	1.85±.06[a]
LA	94.6±1.4[a]	1.69±.07[b]

[a,b,c,d]Means within a column and within an underlined and bold item group with no superscripts in common are significantly different (*P* < .05).
[e]Ewes are at least 7/8 dairy breeding with 3/4 or greater of EF breeding. A few ewes contain no LA breeding.
[f]Ewes are at least 7/8 dairy breeding with 3/4 or greater of LA breeding. A few ewes contain no EF breeding.

Lactation. The effects of lactation number, weaning/milking system, ewe breed group, and sire of ewe are presented in Table 3. Only milk, fat, and protein obtained from ewes while they were machine-milked were used to determine performance for lactation traits. Milk produced during any nursing period was not estimated.

All measures of lactation performance increased (P < .05) as the ewes progressed from 1st through 3rd and greater lactations. The effects of weaning/milking system have been reported by our group previously (McKusick et al., 2001). The ranking of the systems from highest to lowest for lactation length and yield of milk, fat, and protein was: DY1, MIX, and DY30. The lowest percentage of milk fat was found in MIX milk. This is due to an especially low fat content of milk obtained during the once-a-day milking during the first 30 days of lactation when the ewes spend half of their day nursing their lambs. During this period, MIX ewes do not have complete milk ejection in the parlor, and milk fat is retained in the udder; supposedly to be released to their lambs later (McKusick et al., 2002).

There did not appear to be large breed effects on milk yield or lactation length. Within the dairy breeding percentage subgroups of 1/2 and 3/4 quarters dairy breeding, LA breeding tended to reduce milk yield, but in the 7/8+ dairy breeding group, the higher percentage LA ewes had somewhat greater yields. Averaged over all ewe breed groups, ewes with an EF sire produced 14.6 kg more milk over a 6.2 day longer lactation period than ewes sired by a LA sire, but these differences were not statistically significant.

Table 3. Lactation traits (mean ± SE)

Item	Milk, kg	Lactation length, d	Fat, kg	Fat, %	Protein, kg	Protein, %
<u>Lactation</u>						
1st	162.1±8.3^{c}	137.8±3.6^{c}	9.1±.5^{c}	5.61±.08^{c}	7.6±.4^{c}	4.67±.05^{b}
2nd	219.5±9.0^{b}	160.3±3.9^{b}	12.8±.6^{b}	5.79±.09^{b}	10.9±.4^{b}	4.97±.05^{a}
3rd+	254.4±11.9^{a}	174.9±5.5^{a}	15.6±.7^{a}	5.95±.12^{a}	13.0±.6^{a}	5.00±.07^{a}
<u>Weaning system</u>						
DY 1	234.1±8.9^{a}	173.9±3.7^{a}	13.9±.5^{a}	5.80±.09^{ab}	11.6±.4^{a}	4.84±.05^{b}
MIX	215.6±11.6^{b}	164.2±5.7^{a}	12.5±.7^{b}	5.66±.11^{b}	10.6±.6^{b}	4.85±.07^{ab}
DY30	186.4±9.7^{c}	134.9±4.4^{b}	11.1±.6^{b}	5.90±.10^{a}	9.4±.5^{c}	4.94±.06^{a}
<u>Ewe Breed group</u>						
1/2EF	208.5±11.1^{bcd}	165.9±4.6^{ab}	12.5±.7^{b}	5.88±.12^{b}	10.3±.5^{b}	4.83±.07^{bc}
1/2LA	190.2±12.0^{d}	155.0±4.7^{bcd}	12.6±.7^{b}	6.55±.12^{a}	10.1±.6^{b}	5.28±.07^{a}
3/4EF	199.0±13.5^{bcd}	152.4±6.0^{cd}	10.9±.8^{b}	5.27±.14^{d}	9.5±.7^{b}	4.59±.09^{d}
1/2EF,1/4LA	252.6±14.3^{a}	170.6±6.4^{a}	14.9±.9^{a}	5.86±.15^{bc}	12.5±.7^{a}	4.90±.09^{b}
1/2LA,1/4EF	217.2±15.3^{abc}	160.2±6.5^{abc}	12.4±.9^{b}	5.59±.16^{cd}	10.7±.8^{b}	4.84±.10^{bc}
3/4LA	197.3±14.1^{cd}	146.8±5.9^{d}	12.1±.9^{b}	6.03±.15^{b}	10.1±.7^{b}	5.01±.08^{b}
7/8+(EF,LA)[e]	205.8±14.3^{bcd}	150.8±6.5^{cd}	11.1±.9^{b}	5.25±.15^{d}	9.9±.7^{b}	4.65±.09^{cd}
7/8+(LA,EF)[f]	225.3±16.6^{ab}	159.6±5.9^{abcd}	13.2±1.0^{ab}	5.84±.17^{bc}	11.2±.8^{ab}	4.91±.11^{b}
<u>Sire breed of ewe</u>						
EF	209.4±9.8^{a}	161.4±3.8^{a}	12.3±.6^{a}	5.75±.10^{b}	10.3±.5^{a}	4.81±.06^{b}
LA	194.8±11.5^{a}	155.2±4.0^{a}	12.5±.7^{a}	6.31±.11^{a}	10.1±.6^{a}	5.15±.06^{a}

[a,b,c,d] Means within a column and within an underlined and bold item group with no superscripts in common are significantly different ($P < .05$).
[e]Ewes are at least 7/8 dairy breeding with 3/4 or greater of EF breeding. A few ewes contain no LA breeding.
[f]Ewes are at least 7/8 dairy breeding with 3/4 or greater of LA breeding. A few ewes contain no EF breeding.

Large and significant differences between the two breeds were observed for percentage fat and protein, with the LA superior to the EF. Within each of the percentage dairy breeding subgroups, the ewes with the highest percentage of LA breeding had the greatest percentage fat and protein. Averaged over all ewe breed groups, ewes sired by LA rams had greater ($P < .05$) percentage fat (6.31 vs. 5.75%, respectively) and percentage protein (5.15 vs. 4.81%, respectively). Even though the higher percentage LA ewes often had lower milk production than other breed groups, the higher fat and protein content of their milk resulted in the production of similar amounts of fat and protein.

The LA breed will increase the content of fat and protein in milk compared to the EF breed. Producers selling milk on a component basis or farmstead cheese makers may benefit from the use of LA genetics.

The single ewe breed group with the most outstanding lactation performance was the 1/2EF,1/4LA group. These ewes produced from 27.3 to 62.4 kg more milk than any other group. In addition, they had some of the highest fat and protein contents so their fat and protein yields were the highest among the breed groups.

Conclusions

Based on the results of this study, replacement of 50% EF breeding with 50% LA breeding will have a small effect on lamb growth, will decrease lambs born per 100 ewes exposed by about 15, may result in a slight decrease in milk production (~7%), and will raise fat and protein content of milk by .3 to .6 percentage units.

Since most sheep milk in North America is not sold on a component basis, the infusion of large amounts of LA breeding into EF flocks will likely result in a decrease in net income – primarily from fewer lambs produced. However, infusion of smaller amounts of LA breeding into an EF flock may result in increased lamb and ewe survival due to hybrid vigor while at the same time taking advantage of the positive effect of LA breeding on milk composition. A simple approach to accomplish this would be to use a rotational crossbreeding program with purebred EF and F1 EFxLA rams. Any ewe sired by an EF ram would be mated to an EFxLA ram, and any ewe sired by an EFxLA ram would be mated to an EF ram. A similar number of replacement ewe lambs would be selected from each sire breed. This system would result in a flock in which about half of the ewes would be 83%EF,17%LA and the other half would be 67%EF,33%LA.

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THE EFFECT OF FEEDSTUFF ON MILK FLAVOR

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Abstract

Milk flavor is composed of a variety of chemical compounds, derived from numerous sources. Some compounds found in milk are directly linked to the diet of the animal producing the milk. In many cases, it is uncertain where the compounds originate. Two main hypotheses are that they originate in the plants eaten by the animal or they are products of digestion of precursors. Common animal feeds, such as TMR (Total Mixed Ration), pasture, corn, and hay, as well as a combination of them, can influence milk flavor and composition. Various feedstuffs also affect the performance of the producing animal. In general, TMR-fed cows have greater milk production, body weight, and body condition compared to pasture fed cows. Pasture-fed cows' milk contains more odor-active compounds that TMR-fed cows.

Introduction

Due to the small market for goat and sheep milk, a limited amount of information is available on the effect of feedstuff on sheep and goat milk composition and flavor. Given the complexities of flavor analysis, even cow milk research is very limited. However, most of the details presented in this paper relate to bovine milk. It should be noted that while sheep and goat milk have different composition and functional characteristics compared to cow milk, similarities in diet and milk production exist.

Feedstuff

A variety of feeding techniques exist for milk-producing animals. They include a strict pasture or grass-fed diet, a total-mixed-ration feed (TMR), or a combination of the two. Pasture fed animals generally have a varied diet from one region to the next due to different plant-life in different regions, as well as the influence of weather and other environmental factors. A TMR mix typically contains a variety of grains, seeds, and protein supplement. According to Bargo, "Energy is the primary limiting nutrient for high-producing dairy cows on pasture (Bargo 2002)". Grazing alone may not yield enough energy for high yielding animals, so it is common for farmers to supplement the animals' diet. Alternative supplementation to animal diet may include corn silage or hay silage. Advantages of corn supplementation and/or hay silage include cost efficiency as well as seasonal availability of pasture (Holden 1995).

Milk Flavor Composition

The flavor of milk is composed of a variety of compounds. Numerous studies (Carpino 2004, Bendall 2001, Mariaca 1997, Gordon 1979) have been conducted measuring different compounds associated with milk flavor. In particular, aromatic flavor compounds called alkylphenols greatly influence the “feed flavor” of milk. A few additional chemical c that contribute to the feed flavor in milk composition include methyl sulfide, acetone, butanone, isopropanol, ethanol, and propanol (Gordon 1979).

One study (Carpino 2004) used cheese to identify odor-active compounds in the milk of differently fed cows. Gas chromatography was used to analyze the amount present in the cheese. In particular, more aldehyde, ester, and terpenoid compounds are found in pasture fed cows than TMR fed cows (Carpino 2004). Terpenoids in plants are products of secondary metabolism and may be considered as biochemical indicators to characterize highland cheese (Mariaca 1997). There is a small debate as to whether it is specific compounds found in milk that give it its flavor, or whether it is a concentration of a certain set of chemicals that give it its flavor.

Origin of Aromatic Flavor Compounds

Milk flavor is directly influenced by the diet of the animal producing the milk. For example, in Switzerland it has been known that a “pasture rich in dicotyledons, mostly located in the highland, is said to give cheese a different flavor from that produced from pasture rich in gramineae, located in the lowland (et al Sehovic, 1988, 1991).” This study demonstrates that the flavor of milk is directly influenced by the diet of the animal due to the differences in plant life consumed by the animal.

Knowing that the diet of animals influences their milk flavor, questions arise as to where the flavor compounds in the milk originate. It is possible the flavors in milk are found originally in the plant matter eaten by the cows. One particular study (Carpino 2004) used cheese to analyze the flavor compounds found in milk and suggests that “most of the odor-active compounds ... from pasture-fed cows appeared to be compounds created by oxidation processes in the plants that may have occurred during foraging and ingestion by the cow (Carpino 2004).” In other words, they are present in the milk due to the degradation or alteration of compounds in the plants consumed by the cow. The results of this study demonstrate “clearly that some unique odor-active compounds found in pasture plants can be transferred to the cheese (Carpino 2004).”

However, a different study suggests “differences in milk flavor are primarily caused by concentration differences of a common set of flavor compounds rather than by the occurrence of compounds uniquely associated with a particular feed (Bendall 2001).” This suggests there are basic compounds found in all milk, and different feed types produce different ratios of such compounds, instead of different compounds associated with different feed existing in the milk.

An additional hypothesis is that “volatile plant odors that are inhaled by the cow during consumption of the plants pass quickly through the bloodstream to the milk (Dougherty et al., 1962).”

Effect of Feedstuff on Animal and Milk

Numerous studies (Carpino, 2004, Holden 1995, Polan 1985, Bargo 2002, Kolver 1998) have shown that cows fed with TMR have greater milk production, body weight, and body condition compared to pasture fed cows. In addition, TMR-fed cows' milk contains a higher milk fat content and protein content. Milk production and milk fat lowered only slightly when cows were fed a mixed diet (Kolver 1998, Holden 1995.). However, the same study showed there are up to twenty-seven odor-active compounds identified in milk from pasture-fed cows. In mixed-ration fed cows, only thirteen active compounds were detected. Pasture-fed cows contain a greater number of odor-active compounds than mixed-ration-fed cows did (Carpino 2004).

Corn silage is another feedstuff used for milk-producing animals. One corn silage study (Polan 1985) conducted over a period of three years concluded corn silage was not as effective in maintaining milk production but enhanced milkfat. The same study also concluded limited hay or hay available in paddocks did not increase milk production or milk fat concentration.

Research is still needed to further explore these areas such as originating flavor compounds. In addition, more research may be performed with a variety of animals such as goat, sheep, and cows in other regions. Overall advancement of this knowledge may help farmers produce an optimum product for consumers in the most economic manner worldwide.

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