NUTRITIONAL AND MANAGEMENT FACTORS ASSOCIATED WITH MILK UREA NITROGEN LEVELS IN MARITIME DAIRY CATTLE FED UNDER COMMERCIAL CONDITIONS

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ABSTRACT

Controlled feeding trials have demonstrated associations between milk urea nitrogen (MUN) and protein intake and between MUN and fermentable energy intake. The variation in the total amount of ingested protein had only a slight effect on MUN levels when the ratio between protein and energy was held constant. Most trials have been based on a relatively small number of cows, frequently without access to pasture. Results from a large scale observational study involving Prince Edward Island (PEI) dairy herds would clarify how nutritional and other factors affect MUN in cows maintained under commercial conditions on PEI.

Between October 1999 and January 2001, 83 dairy herds from PEI and 9 dairy herds from Nova Scotia were enrolled in this study. Herds evaluated during the grazing period were divided into two groups: intensive grazing managers and extensive grazing managers. The same herds were evaluated during the confinement period and were classified as being either total mixed ration herds or component fed herds. The study included four data collection periods (minimum of two farm visits and two telephone conversations). During each period, information pertaining to herd management, feeding practices and detailed nutritional data was collected. Throughout the 2000 grazing period, a subset of 18 herds was additionally monitored, on a monthly basis, in order to establish significant factors affecting MUN levels during the grazing period and to evaluate the use of a rising plate meter as a means of evaluating forage biomass availability. Throughout both the full and subset study, feed samples were collected and submitted to the PEI Soil and Feed Testing Laboratory (PEISFTL) for analysis. Data was entered into two computerized ration evaluators in order to establish the protein and energy status of each herd. Ration evaluator outputs and herd management information were then used in multi-level model analyses in order to investigate the relationships that existed among ration composition, nutritional requirements and MUN.

Feedstuff composition was relatively uniform within each of the harvest seasons, between harvest seasons, between provinces and among herd classifications. Herd demographics and management practices were not as uniform. Predicted MUN values were 3.9 units higher on intensive grazing management herds where ryegrass was present when compared to extensive grazing management herds where ryegrass was absent. During the confinement period, detailed Cornell-University of Pennsylvania-Miner Institute (CPM©) Dairy (Version 1.0) breakdown of the energy and protein fractions added very little in our ability to explain the observed variation in MUN when compared to a simple measurement of the total energy and protein ingested. The Spartan© (Version 2.01) protein-energy ratio explained 5.9 % of the observed variation in MUN. Under non-experimental commercial conditions, the relationship between MUN and dietary components is much weaker than found by other researchers. Further analysis, in herds with differing feeding regimes and more variable MUN values is warranted.

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TABLE OF ABBREVIATIONS

ADLIC	Atlantic Dairy Livestock Improvement Corporation
ADF	Acid detergent fiber
AE	Available energy
AF	As fed
AOAC	Official of analytical chemists
AP	Available Protein
BUN	Blood urea nitrogen
BCS	Body condition score
CP	Crude protein
CPM	Cornell - University of Pennsylvania - Miner Institute
CR	Component ration
DIM	Days in milk
DM	Dry matter
DIP	Degradable intake protein
DVE	True protein digested in small intestine
EDE	Energy deficit/excess
EGM	Extensive grazing manager
PER	Protein-energy ratio
FCM	Fat corrected milk
GMI	Grazing management index
G-TMR	Grazing - Total mixed ration
Ha	Hector
IGM	Intensive grazing management
IQR	Inter quartile range
Ln	Natural logarithm
MAFF	Minister of Agriculture Foods and Fishery
Mcal	Mega calorie
MJ	Mega Joule
MLM	Multi-level model
MNPN	Milk non-protein nitrogen
MUN	Milk urea nitrogen
NEFA	Non estrafied fatty acid
NH_3	Ammonia
NDF	Neutral detergent fiber
NE_l	Net energy of lactation
NPK	Nitrogen Phosphorus Potassium
NS	Nova Scotia
OEB	Rumen degraded balance
PDE	Protein deficit/excess
PEI	
PESTFL	Prince Edward Island Soil and Feed Testing Laboratory
PUN	Plasma urea nitrogen

TABLE OF ABBREVIATIONS CONTINUED

RPM	Rising plate meter
RSD	Residual standard deviation
RUP	Rumen undegradable protein
SE	Standard error
TC	Total confinement
UIP	Undegradable intake protein

Chapter 1

Nutritional and Management Factors Associated with Milk Urea Nitrogen Levels : An Introduction and Overview of the "MUN Study"

1.1 Introduction

1.1.1 Composition and origins of milk urea nitrogen

Milk urea nitrogen (MUN) is the urea component of the milk and is the largest component of the non-protein nitrogen (MNPN) in the milk. Milk urea nitrogen is a product of ammonia metabolism which originates from the ruminal breakdown of dietary crude protein (CP) in the rumen and the post-ruminal deamination of amino acids for gluconeogenesis (1).

Release and capture of ammonia in the rumen is affected by the balance and fermentability of carbohydrate and protein in the diet. Lack of carbohydrate relative to high amounts of degradable protein in the rumen will result in increased rumen ammonia levels. Ammonia not incorporated into microbial protein can either flow with the liquid phase from the rumen to the omasum or diffuse across the rumen wall (2). Ammonia escaping from the rumen is transported via blood to the liver where it is converted to the less toxic metabolite, urea. Urea, a highly soluble molecule, is excreted in urine and other body fluids including milk (1).

Dietary components have an effect on rumen ammonia pools (3;4) and, therefore, can affect MUN levels. A feeding trial undertaken by Oltner and Wiktorsson (5) assessed the effects of varying dietary protein and energy levels on MUN (n = 49 cows). They found that variations in the total amount of ingested protein had only a slight effect on MUN levels when the ratio between protein and energy was held constant. Degradability of dietary protein affects rumen ammonia levels. Rosseler *et al.*(6) undertook a feed trial (n = 15 cows) that looked at dietary protein degradability and how it influenced MUN. In their study, plasma urea nitrogen (PUN) and MUN were increased by increases in intake of degradable intake protein (DIP) and undegradable intake protein (UIP) and reduced by increase in intake of degradable energy. Rosseler *et al.* (6) also concluded that subtle imbalances in concentrations of DIP and UIP were overwhelmed by changes in total CP and energy intake. Prewitt (7) evaluated the effects of dietary protein on blood, urine and milk composition in 30 cows. Mean blood urea nitrogen (BUN) levels increased in cows with higher levels of protein intake. Schepers and Meijer (8) utilized data from 11 feed trials (2828 observations, 356 cows, 34 experimental groups) and evaluated protein utilization according to the Dutch DVE (true protein digested in the small intestine) - OEB (rumen degraded protein balance) system. They found a correlation (r) of 0.8 between rumen degraded protein balance in the ration and MUN.

Positive associations between MUN and dietary CP, UIP and DIP and negative associations between MUN and energy intake have been found in all feeding trials reviewed. However these studies are based on a relatively small number of cows, managed in very controlled conditions, frequently without access to pasture. Extrapolation of this research to Prince Edward Island (PEI) dairy farms might be unwise without further field evaluation. Results from a large scale observational study involving PEI dairy herds would clarify how nutritional and other factors affect MUN in cows maintained under commercial conditions on PEI. The desire to pursue this objective initiated the current study.

1.1.2 Potential uses and benefits of MUN

Establishing the efficiency of MUN levels as a herd nutritional monitoring tool under commercial conditions would be very beneficial to dairy producers, nutritionists, and veterinarians. Milk urea nitrogen is a reflection of the rumen environment two to four hours prior to milk collection (11). Utilization of MUN as a nutritional monitoring tool could result in early detection of energy and protein imbalances. Prompt correction of these imbalances could lead to improved protein efficiency and reduced feed costs.

Farm nutritional management changes seasonally. Grazing and non-grazing periods result in clearly demarcated summer and winter feeding management practices. Feeding management during the grazing period can be challenging because the amount and quality of forage consumed as pasture is usually unknown. Because of this, the value of MUN as a nutritional monitoring may be of particular importance during the grazing season.

Regardless of feeding management practices, protein is a very expensive commodity. Validation of the association that exists between MUN and dietary protein and energy could lead to increased understanding and confidence in the interpretations of MUN concentrations when it is utilized as a nutritional monitoring tool.

1.1.3 Multi-factorial nature of dietary protein and energy requirements and delivery

In order to better understand the interactions between ruminal protein and energy and MUN levels, we need to ascertain the protein and energy delivery and requirements of PEI dairy cows kept under commercial conditions.

Protein and energy requirements are based on body weight, milk production, milk fat and milk protein components, stage of lactation, parity and breed. Computerized ration analyzers are able to estimate the nutritional requirements of each cow with the above information. These programs can also estimate the total protein and energy supplied in the diet based on feed sample analysis. In this study, we utilized two computerized ration evaluators: Spartan© (Version 2.01) which originates from Michigan State University and the Cornell-University of Pennsylvania-Miner Institute (CPM ©) Dairy ration evaluator (Version 1.0).

Spartan© was chosen because it is a nutritional program that is widely used in the dairy industry. It computes protein and energy requirements based on milk production, milk components, stage of lactation, breed, and body size. Dietary CP, soluble protein (SP), degradable intake protein (DIP), undegradable intake protein (UIP) and net energy of lactation (NE_l), intake calculations are based on the feed components analysis and the ingredient intake. The program calculates nutritional requirements, intakes, and differences between these two, which then allows the program user to determine if the energy and protein requirements are being met.

The CPM© Dairy ration evaluator was chosen based on the methodology of this program in assessing protein and energy delivery. This ration evaluator partitions protein and energy into fractions based on their degradabilities, which are estimated from traditional laboratory analysis and lignin determination. It expresses energy and protein delivery in terms of available protein (AP) and available energy (AE), which are less widely used terms then CP and NE_l.

The use of ration evaluators permitted the assessment of relationships between MUN and energy and protein requirements and dietary availability.

1.1.4 The challenges

The magnitude of this study offered many challenges. The three largest challenges were:

1) the time commitment required to determine the quality and quantity of feedstuffs being fed on 92 individual farms at four different time periods, 2) ascertaining confidential input values from feed companies, and obtaining non-conventional feed component input values from the feed laboratory required for CPM© dairy and 3) statistical analyses that take into consideration the hierarchical nature of the data.

1.1.4.1 Assessing the quality and quantity of feedstuffs being fed on 92 individual farms at four different time periods

Accurate predictions of the protein and energy status required an assessment of the quality of diets fed to early, mid- and late lactation cows on 92 herds at four times. Each time period represented a two month period of phone calls or farm visits. Quantifying the amount of feedstuffs fed varied from farm to farm. While some producers knew exactly what amount of ration was being fed for a certain level of production, other farms required extensive on-farm data collection including weighing of amounts fed.

1.1.4.2 CPM© dairy input values

The CPM© dairy ration analyzer output is driven in part by non-traditional input values which include lignin and neutral detergent fiber (NDF) degradability. A subset of forage samples underwent a 30 hour *in vivo* NDF digestibility trial. Results of the trial were utilized to validate the CPM© forage library digestibility values. Repeatable lignin results were more difficult to achieve. In-house laboratory and commercial laboratory results were questionable. In the absence of a repeatable lignin test, CPM© library lignin values were utilized.

Entry of commercial dairy ration components into CPM© was problematic. Feed companies did not have CPM© specifications for the various products that they produced. Certain companies were very hesitant to release the confidential information that we required to use the CPM© ration analyzer. This problem was overcome by negotiating a suitable approach with each company as to how confidential feed ingredients could be entered into a custom CPM© library. Co-op, Purina and Shur-Gain were the three major feed companies that agreed to release the confidential information required by the CPM© program.

1.1.4.3 Hierarchical Data

This observational study dealt with 92 herds with data collected over a year and a half. During this period individual farms were contacted at four times. Consequently the data had a hierarchical structure with multiple assessment times within cows, clustered within stage of lactation groupings, clustered within herds. These clusters resulted in the interdependence among observations. Statistical analysis had to account for the lack of independence. Consequently multi-level model analyses were essential for sound statistical conclusions to be made.

1.1.5 Study objectives

The work described in the present thesis was a component of a larger MUN project at the Atlantic Veterinary College. The overall objective of the MUN project was to develop guidelines for the use of MUN values in Atlantic Canadian dairy herds and to evaluate the potential of MUN as a tool for improving nutritional management. In order to produce guidelines that could be utilized in the field, it was first essential to develop a thorough understanding of nutritional and non-nutritional factors that affect MUN levels and the effects of MUN levels on reproductive performance. Then it will be necessary to implement an intervention trial to test the application of the new guidelines and thereby validate the study findings.

The overall objective of this thesis was to evaluate the effects of nutritional factors on MUN in Atlantic Canadian dairy herds. The present thesis had three specific objectives. One specific objective was to evaluate, in considerable detail, the rations being fed to four groups of dairy herds, stratified by season. Herds evaluated during the grazing period were divided into two groups: intensive grazing managers and extensive grazing managers. The same herds were evaluated during the confinement period using the classification of being either total mixed ration herds or component fed herds. A second specific objective was to evaluate the use of a rising plate meter as a means of evaluating the forage biomass availability. Investigation of the relationships that existed among ration composition, nutritional requirements and MUN levels was the third, and ultimate, specific objective.

The MUN project also encompassed a companion thesis (Dr. Pipat Arunvipas) that addressed the following three issues: 1) quality control assessment of MUN determination from the PEI dairy laboratory, 2) the evaluation of the effects of non-nutritional factors (eg cow, breed, age) on MUN, and 3) a comparison of cow level and bulk tank level MUN values. This information will answer many questions pertaining to the accuracy and precision of the testing methodology, the use of bulk tank MUN values as a monitoring tool, and the importance of non-nutritional factors when interpreting MUN values.

A subsequent thesis prepared by another graduate student will include the intervention study, the evaluation of the effects of MUN on reproductive performance and associations between MUN, nutritional status and fecal nitrogen content.

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Chapter 2

Herd Nutritional Management Summary

2.1 Introduction

Feed trials have shown positive associations between MUN and dietary protein, UIP, DIP and a negative association between NE_l and MUN (1-5). Certain studies have pointed out the importance of the overall dietary protein-energy ratio and how the overall CP can mask UIP and DIP imbalances (1;3). These feed trials consisted of a relatively small number of cows. A large scale observational study involving PEI dairy herds was designed to clarify how nutritional, and other factors affect MUN in cows maintained under commercial conditions on PEI.

Protein supplementation, forage quality, feed delivery systems and pasture management differ among farms. Each of these variables affects herd protein and energy status. An individual cow's protein and energy requirements will vary depending on her lactation number, days in milk, body weight, milk composition and milk production. Because MUN should, in theory, be reflective of the interaction that exists between the requirements and availability of protein and energy, the importance of these nutritional management factors under field conditions as predictors of MUN must be explored.

The first step in evaluating the effects of nutritional factors on MUN concentrations under commercial conditions is to determine what is being fed on the individual farms. Herd nutritional management is influenced by season. Most of the PEI herds enrolled with the Atlantic Dairy Livestock Improvement Corporation (ADLIC) utilize pasture. Pasture utilization and management generated three herd classifications: extensive grazing management (EGM), intensive grazing management (IGM), and total confinement (TC) herds. Winter nutritional management resulted in two herd classifications: total mixed ration (TMR) and component ration (CR) herds.

The overall objective of this chapter is to describe the nutritional management of the 92 study herds that all operated under different commercial management conditions. The specific objectives were to describe: what was being fed, how it was being fed and the feedstuff composition during the grazing and non grazing periods.

2.2 Materials and Methods

2.2.1 Study herds

2.2.1.1 Farm Categorization Definitions

Initial summer farm categorization was based on grazing management data from a 1999

ADLIC survey of management practices. Herds were classified as total confinement herds (TC), intensive grazing management herds (IGM) or extensive grazing management herds (EGM). Total confinement herds were totally confined indoors, year round and may have had access to an exercise paddock. Pastured herds were categorized based on grazing land acreage utilization and the presence of strip grazing. If a herd practiced strip grazing or utilized less than or equal to ten percent of the total available grazing land acreage at any given point in time during the grazing season, it was defined as IGM. Extensive grazing management herds consisted of the remaining herds that did not meet the TC or IGM definitions.

The winter nutritional management classification was based on feed delivery. Herds feeding only a TMR or herds feeding a TMR with supplementation of high producing cows by a computer feeder or grain in the parlor, were defined as TMR. Herds feeding the components of the diet separately were defined as CR.

2.2.1.2 Herd selection

In total 83 dairy herds from PEI and 9 dairy herds from NS completed the study. Herds were selected from among those enrolled in ADLIC . This regional corporation monitors milk production, milk quality and milk components, including MUN. One hundred and ninety three PEI herds were enrolled with ADLIC at the time of herd selection (August 1999). Herds were required to have a minimum of 15 milking cows and at least two milk tests in the previous six month period. Herds not meeting these requirements were excluded from the sampling frame.

The number of herds to be selected for the study included representation of feeding systems in both winter classification (minimum 30 TMR herds and 60 CR herds) and summer classification (minimum of 30 herds in each of the 3 categories: TC, EGM and IGM). Definitions of these three categories follows.

The nutritional management information needed to categorize herds as IGM, EGM or TC was ascertained from a survey (Appendix A) that we designed at the Atlantic Veterinary College (AVC) and completed with the assistance of ADLIC field persons during the summer of 1999. The information captured in this survey was the basis for the initial summer 1999 and winter 2000 classification. When the number of herds meeting the nutritional management classification exceeded the number required, a random numbers table was utilized to select the study herds. Prince Edward Island (PEI) had an insufficient number (22) of TC herds to meet the 1999 summer nutritional management classification study requirements. With the assistance of a Nova Scotia (NS) veterinarian, ten TC herds were recruited from that province for the study.

Four TMR herds included in the winter classification utilized pasture during the summer period. These herds were defined as grazing TMR's (G-TMR) and were excluded from the summer nutritional management assessment.

In total, 85 PEI herds and 10 NS herds were identified, and producers were contacted by telephone to determine if they would be willing to participate in the project. Only one herd was unwilling to participate in the project, producing a response rate of 99 %. This herd was in the EGM group and therefore was replaced, using the next herd in the random numbers table. From the 95 herds originally selected, one PEI herd was excluded from the project because ADLIC testing was not consistently done. A second herd was excluded due to a lack of owner compliance. Nine of the 10 NS herds completed the study. One herd was excluded because spring and summer feed analysis were performed at a feed laboratory other than the Prince Edward Island Soil and Feed Testing Laboratory (PEISFTL). As a result, 83 PEI and 9 NS herds formed the final study population.

2.2.1.3 Summer 2000 and Fall 2000 herd categorization

After completion of the study, herd classification was validated using a grazing management index (GMI) that was generated from detailed information captured during multiple farm visits and telephone conversations. Certain criteria, outlined below, lead to categorization into each classification. If herds did not meet these classification criteria the GMI was utilized to classify the herd. The following grazing management practices resulted in immediate herd classification: stocking densities greater than 10 animals hectare^{-1} were classified as TC; continuous grazing of the same pasture all summer or monthly paddock rotation resulted in an EGM classification; and strip grazing or an intensive paddock rotation where 30 individual paddocks were present and cows were moved daily resulted in IGM classification.

The GMI ranged from 0 to100 and was based on the sum of the grazing management relative scores (RS) (max. 75) and the sum of the grazing land management RS (max. 25). An example calculation of the GMI is presented in Appendix B. Three variables were utilized to assess the level of herd grazing management: stocking density, acreage utilization and grazing period. Four variables were utilized to assess the level of herd grazing land management: re-seeding frequency, application of chemical fertilizer, application of ammonium nitrate and manure application to the July 2000 grazing land.

Acreage utilization was defined as the total available grazing land (hectare) in July 2000 divided by the largest paddock (hectare) utilized in July 2000. Stocking density was defined as the total number of lactating dairy cows divided by available grazing land during July 2000 (cows hectare $^{-1}$). The grazing period equaled the average number of days that cattle would occupy a paddock in July 2000. Each of the three continuous variables were weighted equally and received a relative score (RS) (Appendix B, Table B-4) between zero and 25.

Each of the three grazing land management dichotomous variables (chemical fertilizer, ammonium nitrate and manure) received a score of 0 if not practiced or 6.25 if practiced. Seeding frequency received a RS between 0 and 6.25 using the RS formulae ant the variable score which measured the re-seeding frequency. See appendix B for details.

For the stocking density and acreage utilization variables, IGM farms would have higher RS values (maximum 25), whereas EGM farms would have lower RS values (minimum 0). For the grazing period variable, the RS value for IGM farms was lower than EGM farms (minimum 0-maximum 25). Grazing period RS values were amended by subtracting the initial RS from 25, and thereby maintaining similar directions in the relative values of the RS among the different variables. The re-seeding variable RS was also reversed because IGM practices resulted in RS approaching 0 and not 6.25. Therefore, re-seeding RS values were amended by subtracting the initial RS from 6.25.

The sum of the three grazing management and the four grazing land management variable relative scores generated the GMI. Higher GMI values corresponded with higher intensity of grazing management. The grazing management index was approximately normally distributed. The median score (47.43) was utilized as a threshold value to classify herds to divide herd numbers equally between IGM and EGM groups.

2.2.2 Farm visits and data collection

The first goal of the each data collection period was to record basic herd management practices. The second was to identify and quantify the various feedstuffs that were being fed to cows at 50, 120 and 200 days in milk on the ADLIC test day. Each data collection period, with the exception of fall 99 included an observation on ionophore utilization, grain processing and pasture fertilization.

During farm visits forage and grain samples were collected. When researchers determined that they did not have a forage analysis that represented the forage being fed at the time of a telephone interview, individual herds were revisited and a sample was again collected. Forage and corn silage sampling protocols depended on the method of silage storage. Table 2.1 describes the silage sampling technique. This sampling technique was utilized on all farm visits. Once collected, samples were refrigerated and submitted as soon as possible to the PEISFTL to determine composition. Table 2.2 contains information on the types of analysis performed.

Once the data were collected, they were entered into CPM© and Spartan© dairy ration evaluation models in order to generate output values required to assess the nutritional status of the study herds.

2.2.2.1 Fall 1999 data collection

All 85 PEI study herds were visited between October 29, 1999 and January 15, 2000. The NS herds were visited by the NS veterinarian between December 4 and December 30 1999. During this time, a survey (Appendix C-1) was completed.

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2.2.2.2 Spring 2000 data collection

The Spring 2000 nutritional data were collected between March 15 and May 3, 2000 by

Table 2.1: Sampling techniques pertaining to silage and hay storage and compaction.

Storage	Compaction	Number of samples collected
Round bale	n / a	2 to 3 core samples from 5 to 6 bales
Ag - Bag	n / a	4 to 5 hand fulls from face of silage pile
Upright silo	n / a	4 to 5 hand fulls from freshly unloaded pile
Bunk & heap silo	light	4 to 5 hand fulls from face of silage pile
Bunk & heap silo	heavy	7 to 8 core samples from face of silage pile

Table 2.2: Summary of procedures performed on various feedstuffs at the PEI Soil and Feed testing Laboratory.

Analyses	Procedure	Grain	Silage	Hay	Corn silage	Pasture
Crude Protein	AOAC 990.03 (16)	X	X	X	X	X
Soluble Protein	Pichard DGR and Van Soest PJ (17)		X	X	X	X
Bound Protein	AOAC 990.03 (16)		X	X	X	X
Net Energy of Lactation	Calculated [a]	X	X	X	X	
Acid Detergent Fiber	ANKOM	X	X	X	X	X
Neutral Detergent Fiber	ANKOM	X	X	X	X	X
Minerals [b]	AOAC 968.08	X	X	X	X	X

[a] Calculation based on acid detergent fiber and forage classification (Table 2.3).
[b] Minerals recorded: Ca, P, Mg, K, Cu.

telephone for all PEI herds, utilizing the Spring 2000 Nutritional survey (Appendix C-2). Data for the ten NS herds were collected between April 10 and May 23, 2000.

2.2.2.3 Summer 2000 sentinel pasture herds

Three IGM and three EGM herds from each of the eastern, central and western regions of PEI were randomly selected using a formal random procedure. These 18 herds were selected as sentinel pasture herds. Between June 12 and September 29, 2000, the sentinel herds were visited within 48 hours after an ADLIC test.

During the farm visit, the Summer 2000 Pasture Survey was completed (Appendix C-3). Pastures were walked in a "W" pattern in order to collect a representative sample of the forage ingested by the cattle on the ADLIC test day. Sample collection consisted of taking a grass clipping every tenth step of the walk. Because grazing animals prefer green, leafy and more nutritious parts of the plant, this was considered when the grass clipping were collected. The composite grass sample was submitted to the PEISFTL for analysis. These 18 sentinel herds were the basis of the summer 2000 pasture study which will be discussed in chapter 4.

Estimates of available forage mass were also obtained using the Farm Tracker Electronic Rising Plate Meter (B.M. Butler Computing Ltd. PO Box 1793 Palmerston North, New Zealand). Estimates of the pasture availability were made while collecting the grass clippings (See Chapter 3 of this thesis for more detail).

2.2.2.4 Fall 2000 data collection

Prince Edward Island herds were visited between October 20, 2000 and January 15, 2001 and NS herds were visited between January 15, 2001 and February 28, 2001 to complete the final farm visit survey (Appendix C-5). In total, eighty PEI herds and ten NS herds were visited within 48 hours from an ADLIC test. For logistic reasons, three PEI herds were not visited; pertinent grazing management information for these herds was collected by telephone, for the previous grazing season. Appropriate feedstuff samples were collected from the 90 visited farms, as described in Table 2.1. At this farm visit, detailed grazing management information was also gathered.

2.2.3 Feed composition

Depending on the feedstuff submitted to the PEI feed analysis laboratory, various analyses were performed. Table 2.2 summarizes the feed analyses and procedures performed by the PEISFTL.

The PEISFTL categorizes forage types based on information of forage species provided at the time of sample submission. If no forage species was available at submission, the sample was labeled mixed silage by the laboratory. In order to avoid mis-classification of forages in this study, forages were reclassified based on obtained calcium values. For grass and legume forages, the calcium values were 0.6% and 1.1%, respectively. Forages with calcium values in the range of 0.6 % to 1.1 % were classified as mixed silages. These threshold values were established by consulting with four regional agronomists (Table 2.3) and calculating the average values of their responses. Net energy of lactation (NE_l) values are based on forage classification and acid detergent values (ADF) values. When forages were reclassified, NE_l values were recalculated using the appropriate equations listed in Table 2.4.

2.2.4 Data Management

2.2.4.1 Feed Composition Data

Feed composition data were transferred electronically from the PEISFTL to the Atlantic Veterinary College. A computer program, DBMS Copy (version 6.0), was utilized to convert these files into a Quattro Pro file where extraneous data (eg laboratory codes and formulae) were deleted. The Quattro Pro file was then transferred into Stata 6.0 (6) which was merged with the master data file of herd nutritional management data. All merged feed composition data were individually validated by the researchers.

Table 2.3: Regional agronomist opinions pertaining to calcium levels in grasses and legumes.

Regional specialist	Calcium %	
	Grass upper threshold	Legume lower threshold
Nova Scotia agronomist 1	0.7	1.1
PEI agronomist 1	0.6	1.1
PEI agronomist 2	0.6	1
New Brunswick agronomist 1	0.5 to 0.6	1 to 1.3
Average	.6	1.1

Table 2.4: Forage net energy of lactation (NE_l) equations utilized by the PEI Soil and Feed Testing Laboratory.

Forage	Formulae	Maximum value
Grass	$NE_l = 2.45 - (0.032 * \% ADF)$	1.6
Mixed	$NE_l = 2.30 - (0.028 * \% ADF)$	1.55
Legume	$NE_l = 2.09 - (0.022 * \% ADF)$	1.55

2.2.5 Statistical Analyses

Standard descriptive statistics were performed utilizing Stata 6 (6). Significant differences ($P < .05$) in nutrient composition (ADF and CP) between various sampling categorizations were identified using a one way ANOVA analysis. Sampling categorization included forage type (eg, grass vs legume), individual data collection periods (eg, first cut vs second cut), harvest year (1999 vs 2000) and province (PEI vs NS). Only significant differences were reported.

2.3 Results

In attempt to reduce the volume of tabulated data, 1999 results will only be reported when significant differences exist between the 1999 and 2000 data.

2.3.1 Study herds

2.3.1.1 Herd selection

Table 2.5 shows the herd classification and selection for both summer 1999 and winter 2000. Prince Edward Island had only 22 herds meeting the TC definition and 138 herds meeting the EGM definition. The deficiency in TC herds resulted in 10 TC herds in NS being included in the study.

Table 2.5: Prince Edward Island (PEI) Atlantic Dairy Livestock Improvement Corporation (ADLIC) herd classification and initial PEI ADLIC herd selection for both winter 2000 and summer 1999. classifications.

	Summer 1999 classification					Winter 2000 classification		
	TC[a]	EGM[b]	IGM[c]	G-TMR[d]	Total	TMR[e]	CR[f]	Total
PEI herd distribution (n)	22	138	29	4	193	22	173	193
Herds selected (n)	22	28	29	4	83	22	61	83

[a] Total Confinement Herd
[b] Extensive Grazing Manager
[c] Intensive Grazing Manager
[d] Grazing Total Mixed Ration
[e] Total Mixed Ration Herd
[f] Component Ration Herd

Note: 10 Nova Scotia herds were included in the study to meet the summer TC requirements

2.3.1.2 Farm categorization

Table 2.6 shows the frequency of herds in each category after herd classification validation. There was little change in the total number of herds that made up each category (largest change was observed in the EGM group) although the herds comprising each category did change (Table 2.5). Eight EGM herds were reclassified as IGM and seven IGM herds were reclassified as EGM herds, based on the grazing management index (GMI).

The GMI had a range of 10.3 to 74.6. The mean was 45.6 and median was 47.4. Figure 2.1 shows the relatively normal distribution of the individual herd GMI values. This distribution resulted in the median GMI value being used as the threshold to define IGM herds. Herds with a GMI value greater than the median were classified as IGM. Nineteen herds, 7 EGM and 12 IGM herds (see Table 2.7 for breakdown), were not classified using the GMI due to pre-classification, as described earlier.

2.3.2 Farm visit and data collection

Information pertaining to the amount of individual feedstuffs fed on the individual herds will be described in chapter 4 and 5.

2.3.3 Feed composition

Appendices D through J contain descriptive statistics on CP, SP, bound protein (BP), ADF, NDF, NE_l and Ca levels found in the various feedstuffs fed during the four data collection periods.

Table 2.6: Prince Edward Island (PEI) and Nova Scotia (NS) individual herd classification changes resulting from the summer 2000 grazing management index and the fall 2000 herd classification.

	Summer					Winter		
	PEI TC[a]	NS TC[a]	PEI IGM[b]	PEI EGM[c]	PEI G-TMR[d]	PEI TMR[e]	NS TMR[d]	PEI CR[f]
Initial herd [g] classification (n)	22	9	29	28	4	22	9	61
Reclassified to TC[a]	+2	0	-1	-1	0	N/A	N/A	N/A
Reclassified to IGM[b]	-1	0	+9	-8	0	N/A	N/A	N/A
Reclassified to EMG[c]	0	0	-7	+7	0	N/A	N/A	N/A
Reclassified to TMR[e]	N/A	N/A	N/A	N/A	N/A	+2	0	-2
Reclassified to CR[f]	N/A	N/A	N/A	N/A	N/A	-1	0	+1
Net change	+1	0	+1	-2	0	+1	0	-1
Final classification [h]	23	9	30	26	4	23	9	60

[a] Total confinement herd
[b] Intensive grazing management herd
[c] Extensive grazing management herd
[d] Grazing total mixed ration herd
[e] Total mixed ration
[f] Component ration
[g] Summer 1999 and winter 2000 classification based on 1999 Atlantic Dairy Livestock Corporation survey (Appendix A)
[h] Summer 2000 classification based on GMI and\or detailed information gathered on farm visits. Fall 2000 classification based on detailed information gained on the fall 2000 farm visit.
N/A = Not applicable

Figure 2.1: Histogram representing the individual Grazing Management Index (GMI) distribution among 83 PEI dairy herds.

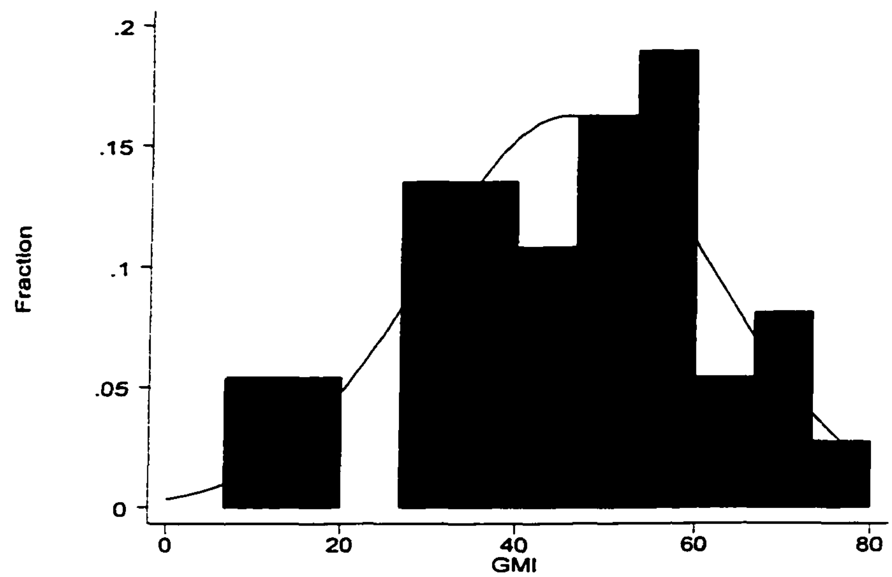

Table 2.7: Fall 2000 classification rationales and the number of herds classified as a result of the individual rationales.

Herd classification	Classification rational	Number of herds
Extensive Grazing Manager	Continuous grazing herd	5
	Extended grazing rotation herds (30 d)	2
	Grazing management index	19
	Total	26
Intensive Grazing Manager	Strip grazing	11
	Intensive paddock rotation	1
	Grazing management index	18
	Total	30
	Overall total	56
Grazing total mixed ration herds		4

For purposes of classification, forages were assigned using the average threshold values from Table 2.3.

Table 2.8 summarizes forage classification descriptions based on reported forage type and calcium classification. Calcium ranges were larger when forage classification was based on reported forage type. When classification was based on % calcium levels, as opposed to reported forage type, there were more forages classified as grass and legume and fewer classified as mixed. The average NE_l values resulting from both classifications were very similar. Only three NS forages appeared to be improperly classified when calcium values were assessed. These three silages were re-classified using the same threshold values that were utilized for the PEI herds and NE_l values were adjusted accordingly.

Table 2.9 summarizes the most common forages fed to dairy cows in PEI. First cut mixed silage was the most common forage fed in both the 1999 and 2000 harvest seasons. Protein levels increased when the amount of legume in the forage increased. In general, the 2000 forages at harvest had a lower CP than similar forage types harvested in 1999. Pasture had the highest average CP of all the forages fed. The same trends observed in the PEI forages were observed in the Nova Scotia forages (Table 2.10), where CP increased with legume content and 2000 forages had lower CP levels when compared to the 1999 CP levels.

Table 2.8: Forage classification based on submission information or forage percent calcium and resulting changes in classification frequency (n), net energy of lactation values and percent calcium ranges.

Classification	Forage	n	Average NE_l [a]	calcium range
Submission	grass	79	1.38	.29 to 1.36
Submission	mixed	302	1.40	.21 to 2.74
Submission	legume	63	1.39	.21 to 1.96
Total		444		
% calcium	grass	123	1.4	.21 to .59
% calcium	mixed	250	1.4	.6 to 1.09
% calcium	legume	71	1.4	1.1 to 2.74
Total		444		

[a] Net Energy of lactation

Table 2.9: Crude protein (CP) and acid detergent fiber (ADF) levels in the most common forages fed (n > 10) among the 83 PEI study herds, 1999 and 2000 harvest seasons.

Forage	Harvest season	n	CP %	ADF %
First cut grass silage	1999	15	14.53	31.28
First cut grass silage	2000	20	12.66	32.80
First cut mixed silage	1999	53	14.95	30.89
First cut mixed silage	2000	45	14.99	28.69
Second cut mixed silage	1999	15	16.30	31.24
First cut legume silage	1999	13	18.64	28.01
First cut legume silage	2000	15	16.48	34.23
First cut grass hay	1999	10	10.60	33.62
First cut mixed hay	1999	11	10.67	34.39
Corn silage	1999	19	12.61	23.50
Corn silage	2000	21	9.44	24.35
Pasture	2000	75	18.81	27.14

Table 2.10: Crude protein (CP) and acid detergent fiber (ADF) summary of the most common forages fed (n > 3), 1999 and 2000 harvest seasons among the 9 Nova Scotia study herds.

Forage	Season	CP		ADF	
		n	%	n	%
First cut grass silage	1999	11	17.10	11	31.64
First cut grass silage	2000	4	14.40	4	32.63
First cut mixed silage	1999	9	18.47	9	31.96
First cut mixed silage	2000	4	18.27	4	30.79
Corn silage	1999	22	9.51	22	20.55
Corn silage	2000	7	8.90	7	22.26

2.3.4 Herd management

2.3.4.1 Herd demographics

Table 2.11 summarizes the average herd sizes and milk production values among the study herds. The Nova Scotia TMR herds were substantially larger than PEI TMR herds and PEI total confinement herds. Intensive grazing management herds, on average, had four more cows then EGM herds. The average milk production was similar between NS herds and PEI TC and PEI TMR herds. Grazing herds had a somewhat lower milk production when compared to the NS and PEI TMR and TC herds. Table 2.12 describes the winter classification housing and feed delivery systems. Fifty six percent of the free stall herds and 18 % of the tie stall herds utilized a TMR feeding system.

It should be noted that the study population was not a representative sample of herds in the industry and, therefore, the demographic descriptions do not represent the state of the industry, but rather a description of the study farms and how these demographics may affect other results.

2.3.4.2 Feed management

Almost 50 % percent of the CR herds delivered their grain manually while only 33 % utilized a computerized system and the remainder utilized an automated, but not computerized

Table 2.11: Average herd sizes and average herd milk production (kg head $^{-1}$day $^{-1}$) for both the winter and summer herd classification, based on a twenty three month (May 99 - March 01) period.

	Winter classification				Summer classification					
	TMR[a]		CR[b]		TC[c]		EGM[d]		IGM[e]	
	n	(kg)	n	(kg)	n	(kg)	n	(kg)	n	(kg)
PEI	63	(30.4)	40	(27.7)	64	(29.9)	37	(26.6)	41	(27.0)
NS	105	(30.9)	N/A		105	(30.9)	N/A		N/A	

[a] Total Mixed Ration Herd

[b] Component Ration Herd

[c] Total Confinement Herd

[d] Extensive Grazing Management Herd

[e] Intensive Grazing Management Herd

N/A = Not Applicable

Table 2.12: Housing and feed delivery systems using the confinement period classification (Fall 2000).

Housing system	Total number of herds	Number (percent) of herds utilizing TMR[a]
Free stall	33	19 (56)
Tie stall	55	10 (18)
Tie and free stall	2	1 (50)
Bedded pack	2	2 (100)

[a] Total Mixed Ration feeding system

grain feeding system. There is a large variation in the feeding frequency of grains, with 33, 10, 23, 15, and 3 percent of the CR feeding grain 2, 3, 4, 5, and more than 5 times per day respectively.

Tables 2.13 & 2.14 outline PEI and NS grain processing techniques. Seventy eight percent of NS herds and 19 % of PEI herds utilized a hammer mill during the grazing season. Rolling was the most popular grain processing technique on PEI herds (50%). Grain processing techniques were relatively the same during the non-grazing period. None of the NS herds were classified "pelleted feed" during the summer grazing and non grazing period in NS. "Pelleted feed" herds consisted of herds where only a pelleted ration and no individual grains were fed.

Table 2.15 summarizes ionophore utilization during the grazing and non-grazing periods in NS and PEI. Data were available from 90, 79, and 86 herds in Spring 2000, Fall 2000 and Summer 2000, respectively. Ionophore utilization was more common on NS herds (56%) than PEI herds (30%). It was also interesting to note that ionophore utilization was more common in PEI TMR herds than in PEI CR herds. Twenty nine percent of NS herds and 17 % of PEI herds utilized ionophores during the grazing season. PEI IGM herds used more ionophores (33%) when compared to Prince Edward Island EGM herds (12%). Table 2.16 outlines TMR feeding frequencies in PEI and NS TMR herds.The majority of the herds fed the TMR one to two times a day. Sixty eight percent of the PEI TMR herds and 85 % of the NS TMR herds fed a TMR one or two times per day.

Table 2.13: Number of farms practicing various methods of grain processing in Nova Scotia (NS) and Prince Edward Island (PEI) study herds during the Spring 2000 non-grazing period using the Winter 99 nutritional management classification.

	Total mixed ration herds		CR[a] herds
Processing	PEI	NS	PEI only
Rolled	12	2	27
Cracked	3	0	2
Hammer mill	3	7	13
Pellets [b]	4	0	19
Total	22	9	61

[a] Component herds

[b] No grains fed on farm, only complete pelleted feed

Table 2.14: Number of farms practicing various methods of grain processing in Nova Scotia (NS) and Prince Edward Island (PEI) study herds during the summer 2000 grazing period on herds classified based on the summer 2000 grazing classification.

	Total confinement herds		Grazing herds	
Processing	PEI	NS	EGM[a]	IGM[b]
Rolled	14	2	11	13
Cracked	4	0	2	5
Hammer mill	2	7	4	3
Pellets [c]	3	0	9	9
Total	23	9	26	30

[a] Extensive grazing managers
[b] Intensive grazing managers
[c] No grains fed on farm, only complete pelleted feed

Table 2.15: Percent of PEI and NS study herds utilizing ionophore during the spring 2000, summer 2000 & fall 2000 sampling periods.

Sampling period	Herd classification	n	%
Spring 2000	TMR[a] Prince Edward Island	20	30
	TMR[a] Nova Scotia	9	56
	CR[b]	61	16
Fall 2000	TMR[a] Prince Edward Island	20	20
	TMR[a] Nova Scotia	5	60
	CR[b]	54	19
Summer 2000	EGM[c]	26	12
	IGM[d]	30	33
	TC[e] Prince Edward Island	23	17
	TC[e] Nova Scotia	7	29

[a] Total Mixed Ration Herds
[b] Component Ration Herds
[c] Extensive pasture manger
[d] Intensive pasture manager
[e] Total confinement herd

Table 2.16: Percent of NS and PEI TMR herds practicing specific TMR feeding frequencies during the fall 2000 non grazing period.

Province	n	1X %	2X %	3X %	4X %	> 4X %
PEI TMR [a]	22	23	45	5	9	18
NS TMR [b]	7	14	72	0	14	0

[a] Prince Edward Island Total Mixed Ration Herds.
[b] Nova Scotia Total Mixed Ration Herds.

Table 2.17 reviews silage storage techniques in PEI and NS. Sixty percent of PEI herds and none of the NS herds fed round bale silage. Bunker silos were the most popular forage storage technique on NS farms (62 %).

2.3.4.4 Grazing land management

Table 2.18 summarizes fertilizer application on IGM and EGM 2000 grazing lands. Fifty percent of the IGM herds and 36 % of the EGM herds utilized some form of organic or chemical fertilizer(ammonium nitrate or nitrogen, phosphorus, potassium).

2.3 5 Factors affecting forage CP and ADF levels

Because multiple comparisons were conducted, significant differences were reported at the more conservative level of significance ($P \leq .01$). The average CP component of forages was significantly different (0.001) between TMR 2000 (15.9) and CR 2000 (14.0).

Table 2.19 summarizes the significant differences that were observed when the various forages were compared between harvest season and province. In general, differences between season and province were small and non-significant. First cut ADF and third cut CP values from PEI legume silages were significantly different between 1999 and 2000.

Table 2.17: Percent of PEI and NS herds utilizing various silage storage techniques during the fall 2000 non grazing period.

Specific silage storage technique	Percent of PEI herds utilizing specific silage storage technique (n = 82)	Percent of NS herds utilizing specific silage storage technique (n = 8)
Round bale silage	60	0
Up right silo	17	38
Bunk	13	62
Heap	6	0
Ag-bag	4	0

Table 2.18: Percentage of extensive and intensive grazing managers that apply manure, nitrogen, phosphorus and potassium (NPK) and ammonium nitrate to the summer 2000 grazing lands.

Fertilizer	Percent EGM [a] herds utilizing specific fertilizer, n = 26	Percent IGM [b] herds utilizing a specific fertilizer, n = 30
Manure	35	60
NPK	36	57
Ammonium nitrate	23	50

[a] Extensive Grazing Management Herds
[b] Intensive Grazing Management Herds

Table 2.19: The effect of harvest season and province on stored forage crude protein (CP) and acid detergent fiber (ADF).Seventy-two pairwise comparison made by location and year. Only comparisons significant at P < .01 are reported.

Silage	Component	Harvest	n	Mean %	Harvest	n	Mean %	P value
3 rd cut legume	CP %	PEI 1999	4	23	PEI 2000	1	18	.007
1st cut legume	ADF %	PEI 1999	37	31.3	PEI 2000	15	32.8	.002
1st cut mixed	ADF %	PEI 1999	82	28.7	PEI 2000	45	24.5	.008
1st cut grass	CP%	PEI 1999	58	14.28	NS 1999	11	17.1	.001
1st cut mixed	CP%	PEI 1999	82	15.7	NS 1999	9	18.6	.001
1st cut mixed	CP %	PEI 2000	45	15	NS 2000	4	18.5	.002

Prince Edward Island first cut grass CP values and first cut mixed silages and CP were significantly different from similar silages originating from NS. First cut mixed ADF values from PEI 1999 were significantly different from the 2000 ADF values.

2.4 Discussion

2.4.1 Study herds

2.4.1.1 Herd selection

Our initial herd selection was based on the presence of strip grazing practices and percentage of maximum acreage utilized at any given point in time. The accuracy of the percent maximum acreage utilized appeared limited as grazing management is affected by more than two variables. Evidence of the inaccuracy manifested itself when herd classification was validated using detailed grazing management information. The initial improper classification did not interfere with the study because each grazing management category had adequate representation after the re-classification (Table 2.5).

2.4.1.2 Farm categorization

Winter categorization was straightforward. Herds either did or did not feed TMR. The TMR definition was broadened to encompass TMR herds that supplemented high producing cows with a computer feeder or extra dairy ration in the milking parlor. The modification in definition was deemed acceptable because in these herds, all cows were ingesting the TMR and only a limited group of high producing cows received additional supplementation. In chapter 5, the relationship between TMR, component feeding and MUN will be explored.

The summer classification was not a straightforward task. There are many interpretations of intensive grazing management (IGM). One committee defined IGM as a type of grazing management that attempts to increase production or utilization per unit area or production per animal through a relative increase in stocking rates, forage utilization, labor, resources or capital (7). Consequently, intensive grazing management is not synonymous with rotational grazing. Hart *et al.* (8) stated that intensive, time-controlled grazing systems are characterized by multiple pastures, high stocking densities, grazing periods that are short enough that regrowth is not grazed within the period, and lengths of grazing and rest periods which increase in length as forage growth rates decrease. Goldberg's *et al.* definition (9) included available pasture land divided into smaller areas, forage rationed according to animal needs, and plants protected from overgrazing.

Grazing land management is expected to affect the forage dry matter yields. Hovingh's (10) research in Atlantic Canada showed that the application of manure, chemical fertilizers and re-seeding was expected to increase forage mass.

Once detailed pasture management data were collected, it was possible to directly classify twelve IGM herds and seven EGM herds based on grazing management practices. The remaining thirty-seven herds required an index that offered systematic classification. Utilizing components of the various grazing management definitions and information that was captured during the study, a grazing management index (GMI) was created. This new classification resulted in seven and eight herds that had been classified as IGM and EGM, respectively, being re-classified as EGM and IGM, respectively. Changes in the classification were possibly due to one of three reasons. Information captured in the initial survey in the summer of 1999 may have been incorrect, grazing management may have changed from one season to the next, or the GMI was better able to classify grazing management practices when compared to the acreage utilization variable used in the initial classification. Information pertaining to changes in pasture management or the validation of the summer 1999 survey was not captured. Even though this information was missing, it is most likely that the changes in classification were due to the GMI ability to properly classify grazing management practices. This is because changing grazing management requires additional resources and it is unlikely that many producers made substantial changes over a one year period. Also, the GMI was likely to be more accurate because it took into consideration three grazing management components and four grazing land management practices as opposed to the initial classification in which only one grazing management component was utilized.

The GMI range (10.3 to 74.6) was indicative of a wide spectrum of grazing management practices. A bimodal curve, indicating two separate grazing management populations, would have simplified classification. However, faced with a normal distribution, the median value (47.4) was utilized to define the IGM threshold. Even though the GMI range was large, it was not possible to separate the herds into two distinct grazing populations.

2.4.2 Farm visit and data collection

The summer 2000 and the fall 2000 farm visits took place within 48 hours after an ADLIC test. The biological rational behind the synchronization of ADLIC tests and farm visits is sound. The temporal proximity of the test and the visits ensured that the samples and information were reflective of what was being fed on the test day, as much as possible. Urea readily diffuses across cell membranes. MUN levels are reflective of the rumen environment two to four hours prior to the test. Serum urea levels peak 1.5 to 2 hours after the rumen ammonia peak, and urea in the milk equilibrates 1.5 to 2 hours later when the rate of change in the serum is 0.5 to 1.0 m moles hr^{-1} (2).

Cow grazing behavior was taken into consideration when grass samples were collected from the various paddocks. Vallentine (11) stated that when samples for nutrient evaluation were taken from the forage stand being grazed, the sample must be representative of what the animal is grazing rather than what is available. Grazing animals select the green, fine, leafy nutritious plant parts. Total clipping of the standing forage to the ground level will underestimate the nutritive value of the ingested forage. In this study, the forage clippings were collected during the pasture walks and were reflective of what the animal would have likely chosen to ingest.

The silage sampling protocols listed in Table 2.1 were established to ensure that silage sampling was consistent throughout the study. It should be noted that in certain instances, the degree of silage compaction determined the sampling technique. When silage was lightly compacted, it was difficult to utilize the standard probes to collect a sample, and therefore it was collected manually.

Crude protein and ADF concentrations were the components chosen to indicate the nitrogenous and energy content of the various feeds, respectively. Crude protein was chosen because all other protein analyses were reported as a percentage of CP. In chapter 5, the importance of protein subfractions on MUN is addressed. Acid detergent fiber was chosen because it is used to calculate NE_l. However, ADF values should only be used to compare samples within similar forage groups as each group has specific formulae (Table 2.4).

2.4.3 Feed composition

The United States-Canadian tables of feed composition (12) listed percent calcium ranges for common legumes (Alfalfa and Red Clover) and grasses (Timothy, Orchard Grass, Ryegrass, Fescue and Blue Grass). From these tables, the legume and grass silage percent calcium ranges were 1.03 to 2.54 and 0.33 to 0.66, respectively. When forages were classified based on the initially recorded laboratory submission identification, the percent calcium ranges (Table 2.8) were not consistent with respect to the NRC tables (12). Regional agronomists were consulted with regards to forage calcium levels observed in the field. Averages of the agronomists responses were similar to the NRC book values (12). Because laboratory submission identification appeared to be frequently incorrect, forages were reclassified based on the average calcium levels . The reclassification resulted in more forages being classified as grass and legume forage and fewer being classified as mixed forage. This shift from mixed to grass and legume forage was expected because at submission, non-identified samples were classified, by default, as mixed.

Individual farms differ with respect to types of forages and harvest dates, forage dry matter content, and feed storage facilities. Kautz *et al.* (13) stated that efficient fermentation ensures a more palatable and digestible feed, which encourages optimal dry matter intake. Key forage management practices include harvesting at proper maturity, ensiling at proper moisture content and chop length and rapid silo filling, with adequate packing and proper sealing of the storage structure. MacKay (14) explained that as forage matures, the proportion of total cell contents decreases in relation to components of the cell wall fractions. Stone *et al.* (15) emphasized the importance of forage percentage dry matter at harvest time. Wetter silages lead to diluted acids, leading to clostridial bacteria dominating the fermentation and decreasing forage palatability (Stone *et al.* (15)). All of these variables play a role in the observed variations in forage quality within and between farms.

In general, the 1999 average CP levels at harvesting were higher than those for the 2000 harvest. Forage CP increased as the legume content increased (Table 2.9 & Table 2.10). This observation conferred confidence in the forage classification based on calcium levels. The significance of the differences that existed between the various forage classifications will be discussed below (section 2.4.5).

2.4.4 Data Management

2.4.4.1 Feed Management

Information was collected on grain processing, delivery and feeding frequency. The majority of herds feed grain between two and four times per day. Grain delivery differences were noted because forty-seven percent of the component herds delivered grain manually. Manual delivery may be less accurate when compared to computer feeders or automated systems. The study surveys were based on what the producer thought he was feeding. If manual delivery resulted in decreased accuracy in the protein and energy delivery, it may affect our ability to predict MUN values in later chapters.

Grain processing techniques differed between provinces. Hammer mill processing was more popular in NS and grain rolling was more popular in PEI (Table 2.13 & Table 2.14). This processing preference may be a function of the grains that are fed and the feeding systems in NS and PEI. In PEI, a great deal of rolled barley is fed. Feeding a total mixed ration (a frequent system in the NS study herds) allows for feeding of finer ground (hammer mill) grains. Both feed delivery and processing will affect the protein and energy availability in individual herds, and therefore must be taken into consideration, when applicable.

Ionophore utilization was found to be less common during the summer months when compared to the winter period. A greater percentage of NS herds utilized ionophores when compared to PEI herds (Table 2.15). All NS study herds had a common nutritional advisor and this higher level of ionophore use may have reflected this individual's preference.

TMR feeding frequency was similar among TMR herds. The majority of herds fed the TMR once or twice per day (Table 2.16). There was a remarkable difference between NS and PEI silage storage techniques. Sixty percent of the PEI herds fed round bale silage. None of the NS herds utilized this storage technique (Table 2.17). Because round bale silage has a long chop length, its rate of rumen passage will be less than silage with a shorter chop length (18). Traditionally, tower, bunk, heap or Ag-bag silos store silages have a shorter chop length. Tower silos having the shortest chop length to enable the silage to be blown up to the top of the silo. Because forage processing affects retention time of particulate matter in the rumen and influences digestion of structural carbohydrates (18) the effects of silage storage should be taken into consideration when possible.

2.4.4.2 Grazing land management

A larger percentage of IGM herds utilized fertilizer when compared to EGM herds (Table 2.18). This observation was expected because twenty-five percent of the GMI was weighted on pasture land management.

2.4.5 Statistics

Six hundred and twenty three individual feedstuffs fed during the study were submitted to the PEISFTL. Pairwise comparisons were made between the average values for forage categories (n=9) for harvest season and province. Of the 72 comparison pairs, there were 6 significant differences in either CP or ADF levels between the two study years or provinces at the $P < 0.01$ level. This level of significance was chosen because of the high number of forage comparisons made. The largest number of significant differences (3) was observed when the PEI 1999 forages were compared to the PEI 2000 forages (Table 2.19). Because the number of significant differences between harvest years and province was minimal (6 out of 72 compairisons), the CP and ADF differences between harvest seasons and provinces was not adjusted for in the mixed model linear regression analysis (Chapters 4-5).

2.5 Conclusion

Summer and winter feeding classifications have been defined and evaluated using the GMI. One way ANOVA indicated that feedstuff composition was relatively uniform within the 1999 and 2000 harvest seasons, between harvest seasons, province and among herd classifications.

Herd demographics and management practices were not uniform. In subsequent work, when applicable, the effects of herd size, milk production, grain feeding delivery in CR herds, grain processing techniques, ionophore utilization and silage storage should be controlled for in relevant analysis.

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Chapter 3

Development and validation of a rising plate meter predictive model applicable to Prince Edward Island permanent pastures during the summer of 2000

3.1 Introduction

In order to better evaluate the relationship among nutrition, pasture management and milk urea nitrogen, estimates of forage biomass (kg of dry matter(DM) ha $^{-1}$) are required. Estimates of forage mass can be utilized to describe observed pastures and quantify available forage. Forage mass can also be utilized to validate the ability of the pasture to meet dry matter intake requirements of the herd, thereby ensuring that the producer's estimates of pasture intake are reasonable.

The most accurate way to determine forage mass is to clip grass samples, dry the sample and weigh it. Because of the large variability in forage quantity and quality within a pasture a large number of samples must be cut (1). This technique is time and labour intensive, and therefore unsuitable if many pastures need to be evaluated, as was the case in this study.

Several rapid and inexpensive methods are available for estimating pasture forage mass. The various methods include visual ground cover estimates, canopy height measurements, the product of visual ground cover estimates and canopy heights measurements, electric capacitance, and bulk heights of the forage canopy compressed by a weighted disk or board (disk meter) (2). This last method holds particular promise as a good compromise of speed, expense and accuracy, and is the subject of this paper.

Several types of disk meters have been employed to estimate pasture mass. Most of these devices consist of a rigid disk, 0.3 to 0.8 m in diameter, with a hole in the center that accommodates a rod marked in measured increments along its length. Alternatively, a rising plate initially located at the bottom end of a center rod is supported by the canopy while the center rod is pushed through the canopy until it contacts the ground. Using this alternative technique, the average plate height and number of observations are automatically recorded on the meter counter (1) .

The accuracy of the rising plate meter (RPM) is dependent on the RPM calibration model. This model is developed to predict the kilograms of dry matter per hectare (kg DM ha $^{-1}$) from the average plate height measurements for each situation in which it is used. Basic statistical principles can be utilized to assess the predictive ability of the calibration model. The objective of this chapter is to describe the development of a RPM predictive model applicable to PEI permanent pasture during the summer 2000 grazing period.

3.2 Materials and methods

One sampling, containing thirty sets of observations were obtained on June 15, July 20, July 27, August 17 and August 29, 2000 (150 observations). Each sampling was carried out on a different farm. An observation set was defined as a rising plate meter reading (RPMR) and a forage clipping dry weight. Observation sets were then utilized to calibrate the RPM. In order to minimize species variation between individual sampling days, calibration data was collected from permanent pastures. Annual ryegrass pastures or newly re-seeded fields were not included in the calibration exercise.

3.2.1 Data collection

The Farm Tracker Electronic Plate meter manufactured by Farm Works (P.O. Box 1793 Palmerston North, New Zealand) was utilized in this study. This rising plate meter plate had a radius of 17.8 cm and covered a 0.1 m^2 area and weighed 0.33 kg. The RPM electronically calculated and displayed the average RPMR height in centimeters. The RPMR represents the distance in cm from the plate to the ground when the weighted disk was fully supported by the herbage on which it was sitting. Forage clippings were obtained from the 0.1 m^2 area that the plate covered. The 0.1 m^2 area was identified using a wire hoop that had a 17.8 cm radius. All vegetation that lay within the hoop was clipped at ground level, placed in a plastic bag, identified with a sample number and frozen overnight. Frozen samples were submitted to the PEISFTL where dry weights were determined. The dry weight of these samples (g of dry matter (0.1 m^2) $^{-1}$) was multiplied by 100 to estimate the kg DM hectare $^{-1}$.

3.2.2 Regression analysis

The RPM calibration equation was derived from linear regression of actual pasture weight from forage clippings as an estimate of the kg DM ha $^{-1}$ on the RPM reading. Two predictive models were investigated because of suspected seasonal effects. A spring model was created from 30 observation sets collected on June15 th The summer model arose from the pooled 119 observation sets collected on the July 20th, July 27th, August 17th and August 31st sampling days.

The statistical significance of the difference between the various linear regression slopes was assessed by examining the interaction terms between each of the sampling periods and the RPMR using linear regression. Variables were transformed prior to linear regression in an attempt to better explain the relationship that existed between the RPM reading and forage mass. Transformation procedures included taking the natural logarithmic (ln) value of the kg DM ha $^{-1}$ and/or squaring the RPMR. Linear regression and residual diagnostics were performed using Stata 6.0 (3) .

3.2.3 Model validation and residual diagnostics

Studentized residuals, leverage values, concordance correlation coefficient, and Cook's distances were calculated and evaluated. For each model, a cross-validation process was carried out by randomly selecting 20 observation sets (2/3 of the population) from the June 15 th sampling period to create a regression model. The new model was utilized to generate predicted values. The correlation coefficient (cross validation correlation) for the new predicted values arising from the observation sets not included in the regression analysis and the estimated kg DM ha^{-1} were calculated. The cross-validation correlation was then squared. This process was done in triplicate using three different sets of randomly selected observation sets (4). For the spring validation, there were 20 observation sets and 10 validation sets whereas the summer validation had eighty sample sets in the model and thirty nine validation sets. The RPM predictive model reliability was assessed by calculating the shrinkage on cross-validation which equals the difference between the r^2 from the initial model and the squared cross validation correlation. If this difference was small, the model was considered reliable (4).

3.3 Results

3.3.1 Data collection

Descriptive Statistics

Table 3.1 summarizes descriptive statistics for the rising plate meter readings by sampling day. The smallest range of rising plate meter readings was on the June 15th sampling day.

3.3.2 Regression analyses

Table 3.2 summarizes the individual sampling day and pooled regression of RPMR on the kg DM hectare^{-1}. The slope from the June 15th sampling was approximately twice the value observed on the other sampling dates and the July \ August pooled slope. The June 15th period had the lowest r^2.

Table 3.3 describes the statistical significance of the sampling period and RPMR interaction terms. The June 15th slope was significantly different from all of the other slopes. The August 31st slope was also marginally significantly different from the July 20th slope but not from the July 27th and August 17th slopes (4).

Table 3.1: Descriptive statistics of rising plate meter readings, by sampling day.

Date	n	Mean (cm)	Std. Dev. (cm)	Min.(cm)	Max.(cm)
June 15, 2000	30	20.8	7.0	9.4	31.2
July 20, 2000	30	21.1	12.3	4.8	43
July 27, 2000	30	14.4	7.2	2.8	33.4
August 17, 2000	29	21.6	9.3	4.0	38.4
August 31, 2000	30	18.2	9.0	5.2	35.2

Table 3.2: Individual sampling day and pooled regression of rising plate meter reading on the kilograms of dry matter hectare $^{-1}$ summary.

Date	n [a]	r^2	Slope [b](SE)[c]	Intercept (SE)[c]
June 15, 2000	30	.59	211 (32)	-1184 (722)
July 20, 2000	30	.87	93 (7)	-825 (168)
July 27, 2000	30	.78	123 (13)	175 (201)
Aug 17, 2000	29	.68	119 (16)	-158 (369)
Aug 31, 2000	30	.78	135 (9)	746 (191)
July & Aug 2000	119	.68	110 (7)	535 (147)

[a] Number of observations

[b] Coefficient for the rising plate meter reading in the simple linear regression.

[c] Standard Error

Table 3.3: Summary of the interaction coefficients between sampling day and the rising plate meter readings values in a multi-variable model with the main effects and interaction terms present.

Sampling date	July 20	July 27	Aug 17	Aug 31
June 15	-117 *	-87 *	91 *	-75 *
	p <.001	p =.003	p =.001	p =.005
July 20		30	26	41 *
		p = .201	p =.185	p =.035
July 27			4	11
			p =.883	p = .645
Aug 17				15
				p =.487

* Significant at the $P < 0.05$ level

Overall $r^2 = .7380$ ($P < .001$)

Table 3.4 represents the r^2 resulting from regression models with RPMR included as linear effects or quadratic effects or log transformed outcome values. Quadratic and log transformations increased the June 15 th model r^2 although the quadratic term in the Spring model was not statistically significant. The July and August r^2 decreased with these transformations. Consequently linear models were assumed to be adequate and the Spring and Summer RPM calibration models were as follows :

Spring kg DM ha^{-1} = - 1184 + 211 RPMR

Summer kg DM ha^{-1} = 535 + 110 RPMR.

Regression diagnostics

The spring model had 2 studentized residuals that were greater than ± 1.96: (2.4, 3.3). The summer model had 7 studentized residuals that were greater ± 1.96 (residual range: -2.2 to 3.4). With a normal distribution, you would expect 6 residuals to be greater than ± 1.96 (n = 119) in the summer period and 1.5 residuals to be greater than ± 1.96 (n = 30) in the spring period. Figure 3.1 & 3.2 illustrate the histogram distributions of the studentized residuals. Two outliers in the spring model make the distribution appear skewed to the right.

Leverage & Cook's distance assessment

When observations with large leverage values were sequentially removed, there was very little effect on the slope. The range of slope changes for the spring and summer were 210 to 215 and 110 to 112, respectively. There were no Cook's values greater than 1, providing no reason for concern of influential values (4).

Table 3.4: RPM and kilogram $hectare^{-1}$ transformation and resulting r^2 summary.

Date	n	r^2 no transformation	r^2 RPM^2	r^2 ln (kg ha^{-1})
June 15, 2000	30	.59	.64	.64
July and Aug, 2000	119	.68	.45	.53

Figure 3.1: Distribution of residuals from linear regression of observed forages prediction (kg ha $^{-1}$) on the rising plate meter readings from the June 15 th sampling (n = 30).

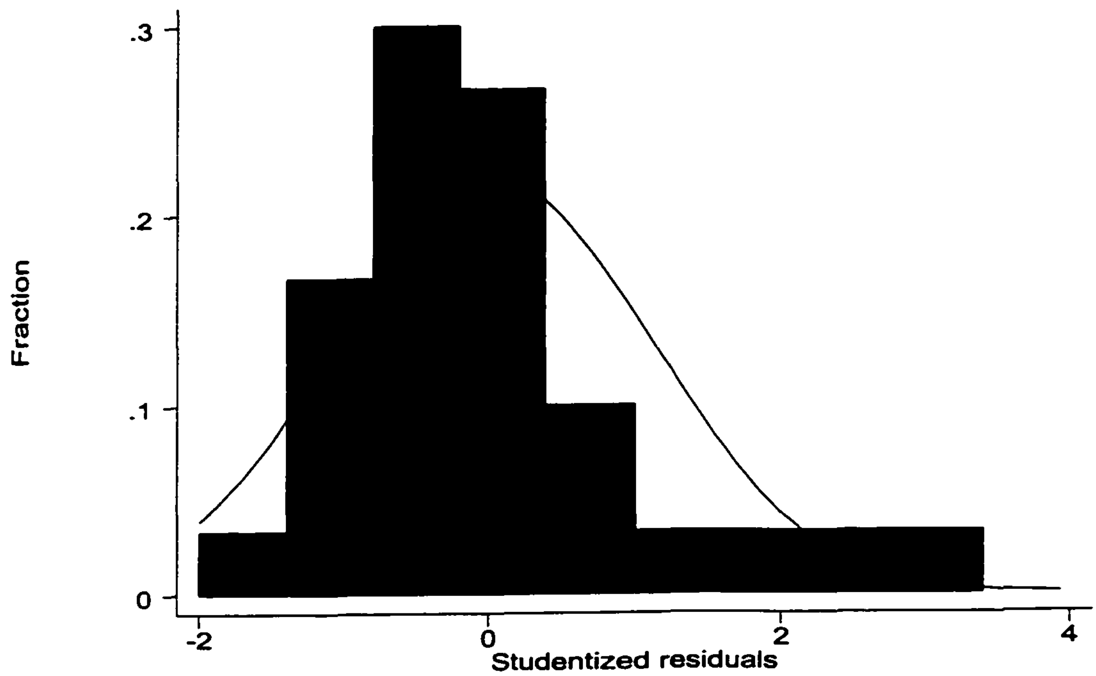
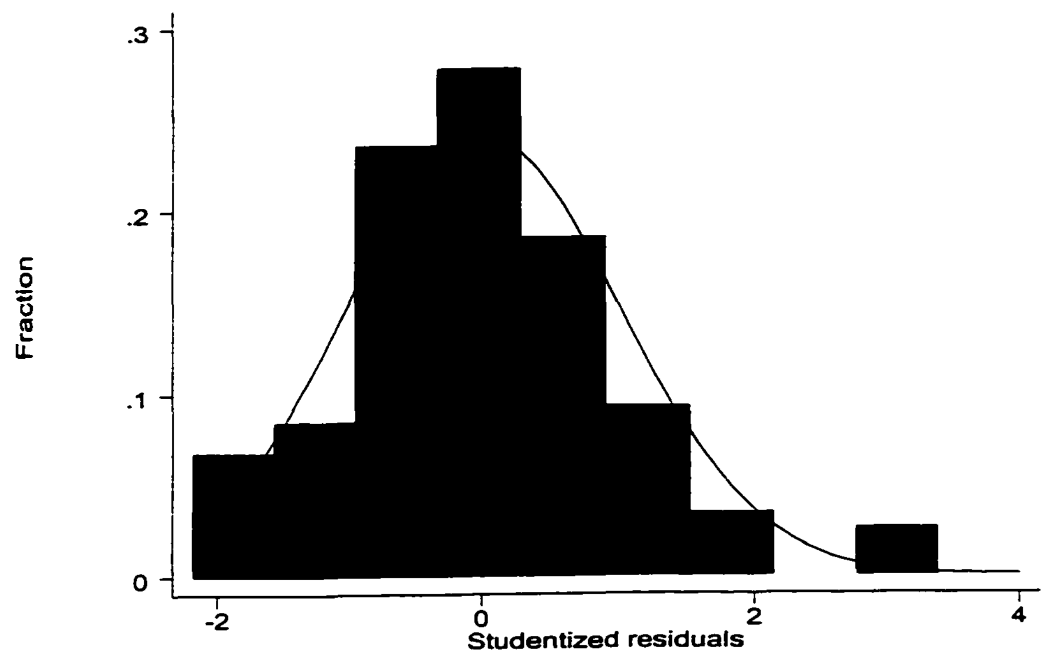


Figure 3.2: Distribution of residuals from linear regression of observed forages prediction (kg ha $^{-1}$) on the rising plate meter readings from the July and August sampling (n = 119).



3.3.3 Model validation

Table 3.5 summarizes the results from the cross validation exercises. The spring and summer models had no shrinkage on cross-validation using two separate data sets and relatively little shrinkage on cross-validation when a third data set was utilized.

Figures 3.3 & 3.4 illustrate the concordance between the predicted and observed values. Both models appeared to under-predict kg DM ha $^{-1}$ when actual values were high and over-predict kg DM ha $^{-1}$ when the actual values were low. There were two forage clipping samples that were substantially under predicted in the June model concordance assessment.

3.4 Discussion

The automated rising plate meter (RPM) was the method selected to estimate pasture mass. The accuracy of this technique is dependent on the calibration of the RPM. The approach taken to calibrate the RPM needs to be based on sound statistical principles.

3.4.1 Data collection

The precision of a non-destructive sampling technique, such as the RPM , is determined by reference to the residual standard deviation (RSD) (5). Bransby *et al.* (6) explained that the formula utilized to calculate the RSD and the standard error of the predicted dry matter yield are such that the RSD will vary with the number of samples (n) according to the following formula $(1 / n)^{1/2}$. This relationship suggests, in theory, that there is little advantage to collecting more than 50 sample sets per calibration. When Bransby *et al.* (6)

Table 3.5: Summer and spring predictive model cross-validation summary for rising plate meter calibration.

Regression model	n	r^2	Random number set	Squared cross validation correlation coefficient
June set1	20	.61	1	.68
June set2	20	.55	2	.62
June set3	20	.65	3	.48
July - Aug set1	80	.70	1	.66
July - Aug set2	80	.68	2	.75
July - Aug set3	80	.67	3	.73

Figure 3.3: Spring model concordance assessment for rising plate meter calibration. Concordance correlation coefficient = .745

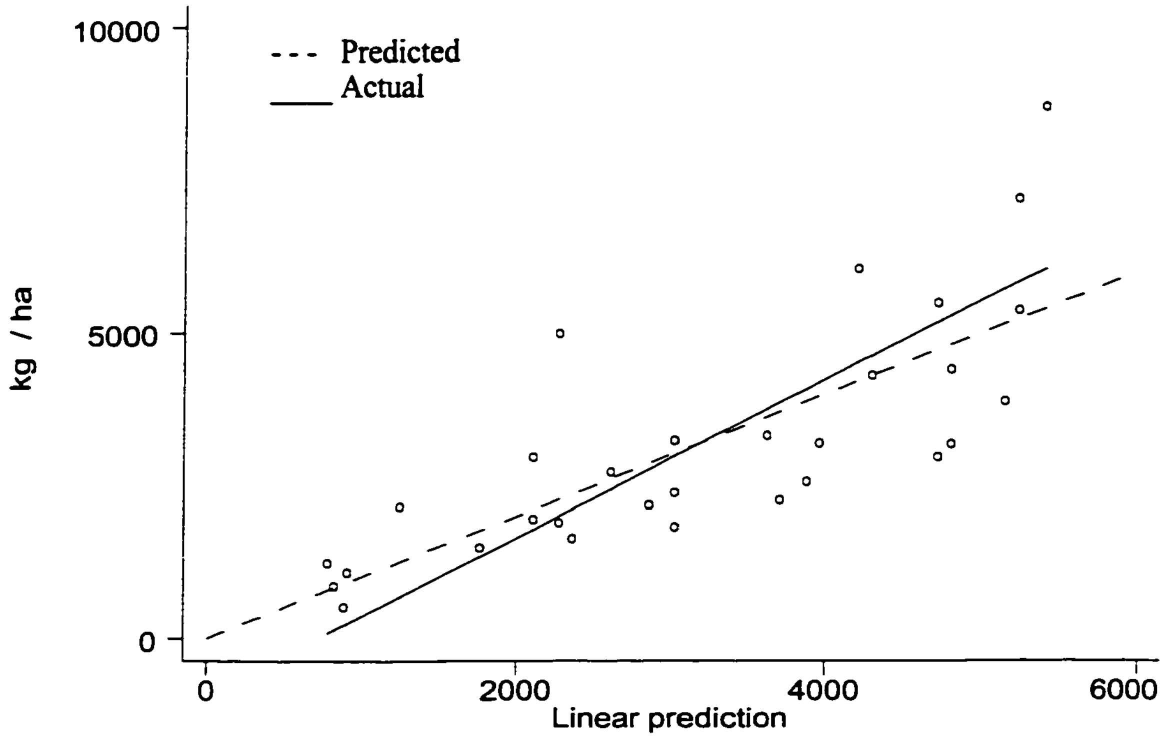
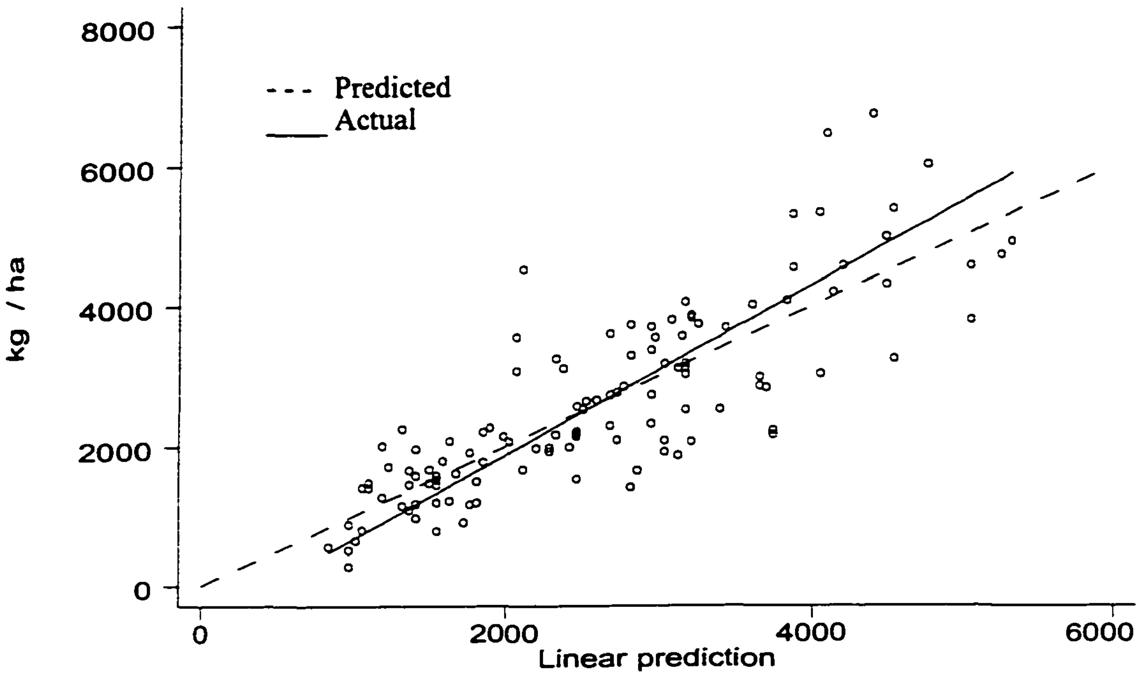


Figure 3.4: Summer model; Concordance correlation coefficient = .812



assessed the relationship between RSD and n, the 600 kg DM ha $^{-1}$ RSD was virtually unaffected when n was greater than twenty five. Rayburn and Rayburn (2) stated that the magnitude of the RSD emphasized the need to take twenty to thirty sample sets per calibration.

In the current study, in order to minimize the RSD and the time spent collecting sample sets, 30 sample sets were collected on each sample day. The June model RSD (1222 kg DM ha $^{-1}$) was higher than the July and August model RSD (743 kg DM ha $^{-1}$). Based on the observed RSD, the July and August model should have a higher level of precision.

3.4.2 Regression analyses

The RPM reading was regressed onto the forage clipping dry matter weight to create a prediction model. The RPM reading represented the resting height of the plate on the sward canopy. There were many biological factors that influenced the resistance of the pasture to compaction, including plant dry matter content, canopy structure and phenological stage (5;6). These biological factors have prompted some researchers to recommend a separate predictive model for each field and season. Bransby *et al.* (6) reported that the level of precision of the RPM was relatively insensitive to changes in disk size and weight when working with a dense tall fescue sward. He indicated that changes from vegetative growth to reproductive growth in a pure sward might alter the predictive ability of the meter. He found marked changes occurring in the regression relationship as the season progressed. In his study, the standard error (SE) for the estimated DM yield in September was 142. The June - July and December SE were 99 and119, respectively. Based on these observations, he suggested that the meter should be calibrated often to ensure reliable estimates throughout the season. Scrinver *et al.* (7) in agreement with Bransby *et al.* (6) stated that the relationship between the herbage weight and RPM reading may or may not be affected by grazing, fertilizer response or maturation. Because the effects of these variables were unknown, he suggested that it was best to calibrate the RPM at least monthly .

On the other hand, Baker *et al.* (8) found that the re-calibration of the disk meter may not be necessary when moving from one pasture to the next if swards were dominated by the same two or three grass species and one or two legume species. When Harmoney *et al.* (9) determined pasture mass using four indirect methods in eleven varieties of grass or legume pastures, he found that the RPM when compared to a height stick or the leaf canopy analyzer, had the most broad application in pastures with varying species. Re-calibration of the RPM was deemed necessary under some circumstances when pastures contained birds-foot trefoil or warm season grasses. Griggs and Stringe (5) found that predictive models based on disk heights appeared to have more universal application across growth periods and cultivars and, therefore, may require less frequent calibration than sward height models. Mitchel (10) found that the variability in the relationship between herbage mass and RPM readings may sometimes necessitate the development of local calibration regressions. In other situations, it appeared possible to pool calibration data over a certain time period. When pooling was possible, the meter offered a regression equation of high precision that could be utilized over a range of situations.

The approach taken was to develop the appropriate prediction models that represented permanent pastures during the summer 2000 grazing period. Permanent pastures were selected because changes in botanical composition in a mixed sward might alter the predictive ability of the meter (6). Permanent pastures in Atlantic Canada are mainly comprised of native grass and legume species introduced by early settlers. The predominant species include blue grass (*Poa* spp.), bent grass (*Agrostis* spp) red fescue (*Festuca Rubra L.*), quackgrass (*Elytrigia repens L. Nevski*) and white clover (*Trifolium repens L.*) (11). Kunelius (12) reported that newly seeded swards can revert to native species within three to ten years after re-seeding, depending on the soil characteristics. Utilization of permanent pastures thereby reduced species variation between individual sampling days and farms.

Regression analysis demonstrated similar slopes on the individual sampling days in July and August. The slope in June (211) was approximately twice that of the pooled (109) and individual slopes (93 - 135) in July and August. The magnitude of this difference was assessed by examining the interaction terms between each period and the RPMR in a linear regression model containing data from all periods. The slope on June 15 th was significantly different from the slopes between July 20 th and August 31 st. As a result, two models were created. The changes from vegetative growth to reproductive growth between the June sampling and the July - August sampling may have been responsible for the significant differences between the spring and summer slopes. The August 31 st and July 20 th slopes were also significantly different ($p = 0.035$). This difference may be reflective of seasonal changes that may necessitate the creation of another predictive model for the fall season. Unfortunately sample set collection ended August 31. Since no sample sets were collected in September, it impossible to confirm the necessity of a fall predictive model. Field RPM readings recorded after August 31 were excluded from the main study due to the uncertainty of the predictive ability of the summer model beyond the last calibration date.

Other researchers have assessed the significant difference of equation coefficients in order to pool data. Scrinver *et al.* (7) utilized a similar approach. In this study (7) the regression coefficients of each calibration equation were statistically compared to regression coefficients of calibration equations from the following date to evaluate the necessity to re-calibrate the RPM. Most regression equations for unfertilized, fertilized, grazed or non-grazed pastures for a given date were similar. Therefore, a single calibration equation combining data from all pastures with similar forage species was used to estimate the standing crop at each calibration date. In all instances, regression equations were different from one sampling date to the next. During weekly visits between April 1977 and June 1979, Mitchel (10) cut and dried grass samples, and created a linear regression for each paddock and each visit. The difference between paddocks and between visit regressions were tested. If the differences were not significant ($P < .05$), then a pooled regression was calculated. The relationship between meter reading and herbage mass was constant over extended periods of time. Consequently, it was possible to include a large quantity of calibration data into a single pooled regression producing a highly precise equation. Over the two year, weekly sampling period, he was able to pool data into18 individual regression models.

In the current study, the r^2 of spring model (0.59) was lower than the summer model r^2 (0.68). The summer model was based on 119 sample sets whereas the spring model was based on only 30 sample sets. Perhaps more of the variation in the data during the spring period could have been explained if a larger number of sample sets had been collected during the spring period. Earl and McGowan (1) found that the calibration accuracy of the model improved when data from the same pasture was pooled. When they used a specific calibration from twelve cuts, a maximum accuracy of ± 150 kg DM ha^{-1} was observed. When they used a pooled calibration with totals of 523 or 302 cuts, an accuracy of 30 - 40 kg DM ha^{-1} was expected.

Variable transformation (RPM^2 and ln (kg DM ha^{-1})) resulted in an improved r^2 (0.62) value for the June 15 sampling period, suggesting that the relationship between RPM and pasture mass may not have been linear during this period. However it is important to note that the quadratic term was not statistically significant. Variable transformation decreased the r^2 during the pooled July and August period. Because transformation results varied, and the quadratic term was not significant, variables were not transformed. Earl and McGowan (1) found similar findings when assessing for curvilinearity. In their data the addition of a squared RPM reading variable only slightly improved the r^2 . These findings prompted the squared RPM reading to be dropped from their equation. Mitchel (10) found that the inclusion of a quadratic term made little difference to the herbage mass estimate.

The June model had the lowest r^2 (0.59) and the smallest RPMR range (9.4 - 31.2) (table 3.1). This small range may be partially responsible for the low r^2. Bransby *et al.* (6)

showed that r^2 increased as the range in plate heights used in calibration increased. He recommended that the range in RPMR be no less than 8 cm when calibrating the rising plate meter. Rayburn and Rayburn (2) reported a calibration equation with an $r^2 = 0.52$. They attributed this low r^2 to the uniform height of the pasture. Earl and McGowan (1) reported that the linearity of the relationship between pasture height and dry matter yield can be best assessed where a wide range of pasture yields are observed. When twelve pastures ranging from 1550 - 5280 kg DM ha $^{-1}$ were included in a single equation, the r^2 was 0.97. Our RPM reading ranges were well above 8 cm and the largest RPMR range had the highest r^2.

Estimates of the calibration r^2 from the literature are highly variable. Castle (13) found that disk height explained 67 to 97 % of the variation in herbage mass of two cool-season grass species under cutting management and 35 to 68 % of the variation under grazed conditions. Predictive models in Griggs and Stringe (5) work had r^2 that ranged between 0.8 - 0.94. Bransby *et al.* (6) had r^2 values that ranged from 0.79 to 0.94, despite a high degree of variability in the pastures. The range of r^2 values in this study (0.59 to 0.86) was comparable to values reported in the literature.

The pooled July and August model had an $r^2 = 0.68$ which was close to the mid-point of the individual model r^2 range. Vertha and Matches (14) found similar results whereby the individual prediction models had wide ranges, and the pooled data r^2 fell near the mid point. Their spring, summer and fall models had the following respective r^2 ranges: 0.15 to 0.84, 0.55 to 0.817 and 0.09 to 0.7, and the following respective pooled r^2 values: 0.50, 0.78 and 0.50. Griggs and Stringe (5) also observed that a model comprised of combined growth periods had levels of precision intermediate to those of individual growth periods. Their work showed that the combined model had an RSD equal to 22.2 and a r^2 equal to 0.94. The individual RSD and r^2 ranges were 16 to 32 and 0.90 to 0.94, respectively.

Regression diagnostics

The histogram of residuals from the spring model was somewhat skewed to the right due to two outliers. However, further regression diagnostics did not indicate that the outliers should be removed, so they were retained in the spring model. The studentized residuals fall within the normal range. There were no Cook's distance greater than one in either of the models.

When individual values with high leverage values were sequentially removed from the model there was very little effect on the slope. The range of the slope variation for the spring and summer model was 207 to 215, and 110 to 112, respectively.

3.4.3 Model Validation

Model validation showed little shrinkage. This suggested that the models were reasonably robust and would be expected to produce comparable results if the model was applied to an unknown permanent PEI pasture. Both models had moderate r^2 values and therefore have moderate predictive abilities.

Lin's concordance correlation coefficient combines the measures of both precision and accuracy to determine whether the observed data deviate significantly from the line of perfect concordance (3). In this analysis, the model predicted values (kg DM ha $^{-1}$) were compared to the actual measured value (kg DM ha $^{-1}$). If the predicted values were equal to the measured values, all data points on a scatter plot with equal scales for actual and predicted values would lie on a line through the origin at 45^0 (3). Both models had moderate concordance coefficients. Graphical assessment showed that both models appeared to over-predict kg DM ha $^{-1}$ when actual values were low and under-predict kg DM ha $^{-1}$ when the actual values were high. There were no comparable estimates of concordance correlation in the published literature.

3.4 Conclusion

The magnitude of the MUN study necessitated a quick and easy way to assess pasture mass. Basic statistical principles were applied to ensure the creation of accurate predictive models. Calibration equations were only generated from permanent pastures and therefore would only apply to these types of pastures.

The evaluation of the predictive ability of the RPM showed that different predictive models were required for the spring and summer periods. The relationship between RPMR and kg DM ha $^{-1}$ appeared linear in the summer. While the linear relationship may not hold true for the Spring period, the predictive ability of a non-linear spring model was not appreciably improved on the linear model. As a result, for ease of interpretation and compatibility with the literature, a linear model was chosen.

Both models have reasonably good predictive ability because they had moderate r^2 values and concordance values. Both models were also reasonably robust because there was little shrinkage on cross-validation. Based on the statistical assessments, both models were valid if the RPM readings were taken from permanent PEI pastures and the sampling period definitions were respected.

3.5 References

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Chapter 4

Observational study of factors associated with seasonal variation in milk urea nitrogen in herds grazing intensively and extensively managed pastures.

4.1 Introduction

Pasture is an important source of forage for PEI dairy farms. During the summer of 1999, ninety percent of the 193 herds enrolled with ADLIC utilized pasture (1). Pasture contributes to both the energy and protein components of the ration, and is particularly important as an inexpensive source of protein. Work done by Berzaghi (2) in Italy showed that cool season grass pastures contained 22 and 28 % CP on a dry matter basis. Researchers in New Zealand (3) found that spring pastures contain 20 to 30 % CP and 5 to 20 % soluble carbohydrate (SC). Fluctuations in CP and SC can affect ruminal ammonia (NH_3) utilization and consequently affect urea levels in the blood and milk (4) .

Plant growth and climatic variations are partially responsible for ranges in pasture CP and SC levels. As pasture matures, the following changes occur: dry matter increases and then plateaus, energy content of the dry matter decreases, protein percentage decreases, and the percentage of dead matter in the pasture increases (5). Hoffman *et al.* (6) acknowledged these changes that occur with plant growth and added that under normal growing conditions, pasture quality would be expected to be highest in early spring and fall. He attributes the lower pasture quality during the summer months to the warmer climate in the northern Unites States which normally increases the structural carbohydrate fraction in cool season grasses. In Spain, CP values reported by Mosquera-Losada *et al.* (7) were high in the spring, declined in the summer with a minimum in August, and then increased again in the autumn. In this study, average CP concentrations were higher in the summer of 1991 than in 1989 or 1990. The observed difference was attributed to wetter growing conditions during the summer of 1991, which promoted plant growth. A study by Soriano *et al.* in Virginia (8) found pasture CP values averaged 19.6%, 27.4% and 23.9% for May, June and July, respectively.

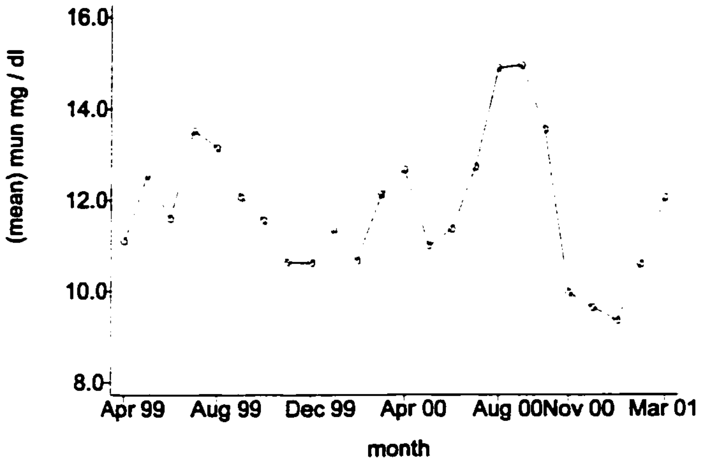
Pasture management practices will also have an effect on CP and SC. If rotation durations are too short in relation to growing conditions, plants will be too low in dry matter. If rotation lengths are too long, there will be increases in pasture dead matter and decreases in energy, protein and digestibility which will lead to lower milk production (5). Crude protein levels have also been reported to increase with stocking density (7). Short regrowth intervals and high grazing intensity increases the protein content of the pasture because plants are kept in a more immature state.

Hongerholt and Muller (9) looked at protein supplements which were high in rumen undegradable protein (RUP) fed to early lactation cows on grass pasture. In this study, they observed high plasma non-esterified fatty acids (NEFA) and PUN concentrations during the first sampling period. This, coupled with a ration evaluation using CPM© dairy, suggested that energy and not protein may be the first limiting nutrient in high yielding cows on pasture. In an attempt to avoid nutritional deficiencies, pastures are often supplemented with concentrates. Moller *et al.* (10) looked at pasture CP, blood urea nitrogen, milk protein and milk fat over a 4 month period. He found that all parameters varied considerably over time, but that in general the lower producing herds had higher blood urea levels, higher pasture CP and lower SC when compared to higher producing herds. Hoffman *et al.* (6) study looked at pasture systems and grain supplementation. They found that higher amounts of grain feeding fed during the six month grazing season did not increase milk production, but improved body weight and body condition scores. Collectively these studies indicate that grazing rations may be energy deficient.

Previous to the initiation of this study, individual MUN values were recorded in PEI beginning in April 1999. Mean MUN values peaked during the 1999 and 2000 grazing periods (Figure 4.1). The elevated MUN values during the 1999 summer grazing period prompted a more intensive study of pasture quality and management during the summer 2000 period, because seasonal variations in MUN may result from changes in both pasture protein and energy intake.

There are many factors that influence pasture CP and SC levels. The effect of pasture

Figure 4.1: Monthly mean PEI MUN values April 1999 - March 2001.



management and dairy ration supplementation on ruminal NH_3 and MUN concentrations needs to be explored if we want to better understand protein and energy interactions during the grazing period. Knowledge gained will assist in making informed nutritional decisions and consequently improve protein utilization in grazing animals. The overall objective of this observational study was to identify the significant factors associated with seasonal variation in milk urea nitrogen, observed on intensively and extensively managed pasture. This objective was met by assessing the impact of pasture management, nutrition, stage of lactation, sample date and pasture supplementation on cow MUN values during the summer 2000 grazing period.

4.2 Materials and Methods

4.2.1 Herd selection

Three intensive grazing management (IGM) and three extensive grazing management (EGM) herds from eastern, central and western PEI were randomly selected from the 83 herds previously enrolled in this aspect of the MUN study. Initial herd classification was based on a survey conducted by ADLIC personnel in 1999 (Appendix A). However, grazing management classification changed in some herds when herds were subsequently classified based on a grazing management index (Chapter 2).

The selected dairy producers were then contacted by telephone to determine if they would participate in the study and all 18 dairy producers agreed to take part in the study.

4.2.2 Herd visits

Between June 12 and September 29, 2000, the 18 study herds were visited within 48 hours after their respective ADLIC test. Pastures that were being grazed on the ADLIC test day were walked in a "W" pattern in order to collect a representative sample of pasture forage. Samples were collected by taking a forage clipping every tenth step of the pasture walk. Cow grazing behavior was considered when the forage clipping was collected. For example, if lush grass and old mature overgrown grass were present, the sample would have been taken from the lush area which is presumably what the cow would have selected. A composite forage sample was created by mixing together all the grass clippings from a particular pasture. The mixed sample was submitted to the PEISFTL for analysis of CP, BP, SP, ADF and NDF. Estimates of available forage mass were generated using the Farm Tracker Electronic Plate Meter® (see Chapter 3) using measurements taken at the points where clippings were collected.

During each visit, feed samples were obtained as described below. Also, a Pasture and Feed Survey was completed (see Summer 2000 Pasture Survey Appendix C-3). This questionnaire identified and quantified, on a daily basis, the various feedstuffs that were currently being fed to cows in the herd at approximately 50, 120 and 200 days in milk. This information was used to determine nutrient intake of the cows in the study herds through ration evaluation. The survey was also used to collect information on grain processing, ionophore utilization and pasture fertilization.

4.2.3 Ration evaluation

All rations were evaluated using Spartan©, a computerized dairy cattle ration evaluator from Michigan State University. This program is a commonly utilized tool in the regional dairy industry for ration balancing. The initial steps of the program require that you define the individual animal in terms of age, breed, body weight, weight changes, stage of lactation, milk production and milk components. These steps are very important because the input values are utilized for all subsequent ration requirement calculations. Example input values and how they were derived are presented in Table 4.1. An explanation of each of these values and derivation is found below.

4.2.3.1 Assumptions and estimates

Body condition scores

Changes in body condition score (BCS) were assumed to be uniform through all herds enrolled in the study. Suggested BCS are 3.0 to 3.75 at calving , 2.25 to 2.75 at peak milk yield , 3.0 to 3.5 at 150 to 200 days in milk and 3.0 to 3.75 at dry off.(5) One BCS point

Table 4.1: List of Spartan© inputs and their derivation.

Input	Value			Derivation
Body Condition Score and Live weight				
Stage of lactation	DIM 50	DIM 120	DIM 200	Assumption: Initial weight (630 kg) and weight change the same on all farms.
Body Condition Score	2.8	2.5	2.9	
Body weight (kg)	594	580	598	Weight changes based on literature.
Daily weight change	-0.7 kg	+0.4 kg	+0.4 kg	
Milk Production & Milk components				
Daily milk production	Individual herd mean corresponding to sampling period and stage of lactation			Mean was calculated from the top 50th percentile over a three month periods
% milk fat				
% milk protein				
Pasture Forage Intake				
Kg of pasture ingested	Difference between predicted dry matter intake (from milk production and other variables) and known amount of dry matter intake			Pasture intake = predicted dry matter intake - (grain dry matter intake + estimated stored forage intake)
Feed Composition				
Feed components	Utilized study value or average PEI value or NRC book value			Forages: average values calculated for the various types of forages submitted for each sampling period Grain: Average PEI values calculated from all PEI feed laboratory submissions between August 1999 and November 1999
Adjusted Crude Protein	Difference between crude protein and bound protein			Adj CP = CP - (CP* % BP/100)

was estimated to be equal to 50 kg. It was assumed that any given animal would freshen weighing 630 kg, lose one BCS unit during the first 70 days of her lactation (-0.7 kg d^{-1}) and regain this one unit of BCS throughout the remainder of the lactation (+0.4 kg d^{-1}). Based on these suggested changes in BCS, the input values for BCS, body weight and daily weight change were calculated (Table 4.1) and entered into the ration evaluators.

Milk production and component estimates

Milk production and component estimates for each herd were calculated for the summer 2000 (June 15, 2000 to September 30, 2000) period. Individual cow milk production values from each herd were obtained electronically from the ADLIC data bank. First lactation heifers were excluded from the data set. Cow tests for cows between 40 and 60 days, 110 and 130 days, and 190 and 210 days in milk were classified as DIM 50, DIM 120 and DIM 200, respectively. Cow tests not included in one of DIM classifications were excluded from the milk production estimates. For each herd, individual cow milk production values were ranked and the cow tests that fell below the fiftieth percentile value were not included in the estimate of the herd mean milk production for each corresponding stage of lactation. The elimination of this latter group of tests resulted in a mean that represented the top producing animals in each stage of lactation grouping. Percent milk fat and percent milk protein values associated with cow tests that fell below the milk production fiftieth percentile were also excluded for each stage of lactation.

Forage intake estimates

Pasture dry matter intakes (DMI) were derived from Spartan© predictions. The pasture dry matter intake equation was as follows:

pasture dry matter intake = predicted DMI - (known grain DMI + estimated silage DMI). Information on grain intake was collected during each farm visit. Silage DMI intake was estimated using retrospective data from the Spring 2000 and Fall 1999 surveys. These two surveys identified the average number of round bales fed or amount of silage fed per day. The average number of bales or amount of silage fed per day during the grazing period was divided by the average number of bales or amount fed during the confined period (fall 1999 & spring 2000). It was then assumed that this proportion of the forage DMI was being consumed as stored forage during the grazing period. The unallocated proportion of the forage DMI was deemed to have come from pasture.

Calculations were made to determine if estimated pasture DMI could be met by the minimum available pasture DMI. Estimates of forage mass were generated by the Farm Tracker® rising plate meter (RPM) spring (June) or summer (July and August) calibration equations (Chapter 3). This estimate was multiplied by the smallest pasture available during the month in which the RPM measurement was taken. This multiplication would give rise to the total minimal amount of DM available. This value was then compared to the actual amount needed which was calculated by summing the individual animal pasture DM requirements of the herd. If the available dry matter forage mass was 200 % that of the herd requirements, the pasture was deemed as being able to meet the herd pasture dry matter requirements (12).

Pasture NE_l estimates

Equations required to estimate pasture NE_l from pasture ADF values were not available from the PEISFTL. Net energy of lactation estimates were calculated in three steps using the following formulae (13, 14):

Pasture metabolizable energy (ME) in mega joules (MJ) = 15.3 - .153 (ADF)

ME (Mcal) = ME (MJ) / 4.186

NE_l = .703(ME(MCal)) - 0.19

All pasture NE_l values were calculated using these three sequential equations.

Feed composition - stored feeds

A total of 117 feed samples (115 forage and 2 grain) were submitted to the PEISFTL. In three instances, when the producer or the feed representative had submitted the feed sample, the feed analysis was incomplete. The average, species specific, forage component values for summer 2000 period were generated from the MUN study database and were used as default values in these three instances. For one feedstuff (sorghum green chop), it was impossible to generate NE_l from the ADF because the conversion equation was unknown. The National Research Council 1989, Sorghum NE_l value was utilized (n = 1) in this unique situation.

Adjusted CP values were calculated for all silages fed in the study to compensate for losses associated with ensiling . The adjusted CP value was calculated using the following equation :

Adjusted CP = CP - (CP * % bound CP/100).

Average grain (barley, wheat and oats) component values were generated from all the grains submitted to the PEI feed analysis laboratory between August 1999 and November 1999. These average grain values were utilized as needed.

4.2.3.2 Ration evaluation calculations

Utilizing the assumptions and estimates in Table 4.1, individual rations, representing early (DIM50), mid- (DIM120) and late (DIM200) lactation animals, were generated for each visit on each of the eighteen herds during the summer 2000 grazing period.

When silage was fed during the grazing period, the silage components were entered into Spartan©. All known parameters from forage analysis (dry matter, ADF, NDF, CP, BP, SP and NE_l) were entered. Required unknown values such as UIP and degradable intake DIP values were determined by selecting a forage from the Spartan© library that closely resembled the farm forage based on botanical species, NDF or ADF content. Grains were treated in the same manner. Commercial product components were ascertained from the appropriate feed companies in order to formulate a product library that would include all the commercial products being fed during the study.

The amount of fed grain and commercial products that was entered into Spartan© was discerned from the information that was collected using the nutritional survey during each farm visit. Two of the eighteen herds enrolled in this study fed a specific milk to grain ratio. The amount of grain fed on these farms was calculated based on the milk production estimates generated from the ADLIC data.

Total energy and total protein intakes were defined as the total NE_l and total CP supplied by the ration. Energy deficit /excess (EDE) and protein deficit /excess (PDE) were defined as the difference between the NE_l or CP supplied by the ration and the required NE_l or CP, respectively. Animal requirements were estimated by Spartan© based on milk production, milk components, body size, changes in body weight and stage of lactation (Table 4.1). These variables were utilized to generate the protein-energy ratio (PER) using the following equation:

PER = (NE_l required / CP required) / (NE_l supplied / CP supplied). The PER was calculated for early, mid- and late lactation animals on each herd visit. These parameters, along with other grazing and lactation information, were utilized in subsequent multiple variable analysis. (Section 4.4.3.2 discusses the ratio rational and examples).

4.2.4 Data analysis

Pasture CP and herd mean MUN between May 28 and September 28, 2000 were evaluated graphically using a locally weighted smoothed mean (Lowess) plot, with a band width of 0.4. One-way ANOVA analysis was used to assess the statistical significance of the pasture components between the various geographical zones and the sampling periods and grazing management.

Multilevel modeling was performed using MLwiN 1.10 (15) to establish the associations between the fixed effects of grazing management, stage of lactation, and their interaction on the EDE and PDE in each stage of lactation group of cows. Herd and visit were included as random effects in both models. In total 186 records were utilized in the analysis.

Multilevel modeling was also used to compute the relationships between PER, grazing management, presence of ryegrass, stage of lactation and their interaction on milk urea nitrogen values in individual cows. Herd, cow and visit were included as random effects. In total, 2327 cow test day records were included in the analysis. Individual cows between 20 and 80 days, 81 and 160, 161 and greater were classified as early, mid- and late lactation respectively. The impact of each significant independent variable on the dependent variable was assessed by determining the change in MUN over the interquartile range (IQR) of the predictor variable. For example, if independent variable "A" had an IQR of 15 units, the multiple level model "A" coefficient would be multiplied by 15 and the change in the dependent variable would be noted as the relative effect.

4.3 Results

4.3.1 Herd selection

The initial goal was an equal distribution of intensive and extensive grazing managers in each geographical zone. Grazing management index reclassification resulted in an over-representation of the IGM herds in central PEI and an under-representation of IGM herds in western PEI. Reclassification resulted in 3 EGM | 3 IGM , 2 EGM | 4 IGM and 5 EGM |1 IGM herds, in eastern, central and western PEI, respectively. The overall distribution was 10 EGM herds and 8 IGM herds

4.3.2 Pasture composition

The level of ryegrass that was utilized during the study is summarized in Table 4.2. Only 20% of the EGM herds utilized ryegrass whereas 63% of the IGM herds utilized ryegrass. The average CP, SP, and ADF values for ryegrass and cool season grasses which were collected on the same day from the same farm were recorded (Table 4.3). Results of

Table 4.2: Distribution of farms utilizing ryegrass at various proportions of the total available pasture and number of farm visits that took place during the Summer 2000 period.

Percent ryegrass relative to total available pasture	Farm (n)	EGM n (%)	IGM n (%)	Herd visits
0 % Annual ryegrass [a]	11	8 (80)	3 (37)	51
50% Annual ryegrass [a]	6	2 (20)	4 (50)	11
100 % Annual ryegrass [a]	1	0 (0)	1 (13)	2

[a] Balance of pasture was non-ryegrass cool season grasses

Table 4.3: Average crude protein, soluble protein and acid detergent values (dry matter basis) and standard deviation (SD) for ryegrass and non-ryegrass cool season grasses collected from the same herds on the same day.

Forage	Ryegrass (SD)	Mixed grass (SD)	T test, p value
% Crude protein	22.45 (3.80)	21.93 (2.70)	.3037
Soluble protein (% of CP)	36.58 (3.79)	37.95 (2.92)	.4418
% Acid detergent fiber	25.08 (3.18)	27.15 (2.93)	.2023

statistical analysis clearly indicated that there were no significant differences between the protein and ADF components of ryegrass and mixed cool season grasses.

The average pooled pasture CP levels, for all 18 herds, during the Summer 2000 pasture study are illustrated in Figure 4.2. The CP nidus occurred in late June followed by an increase in CP as the pasture season progressed. The average herd MUN nidus also occurred during late June and increased until late September (Figure 4.3). The apparent drop in MUN in late September was an artifact resulting from a very small number of late season observations.

Based on one-way ANOVA analysis, the average CP, SP and ADF values were not significantly different between the three regions of PEI (Table 4. 4). Based on the two-way ANOVA analysis, the overall effects of sample date and grazing management and their interaction on CP, SP and ADF were not statistically significant, with the exception of sample date on pasture CP which was significant (Table 4.5). In all three analyses, the zone and the sample date by zone interaction term were not significant. As a result, data from all three zones were pooled in all subsequent analyses.

4.3.3 Ration evaluation

During the study, 64 herd visits took place. Each visit resulted in three rations being entered into the Spartan© program. On six occasions, there were no animals in the predefined lactation group and therefore, rations representing this group of animals were not calculated. In total, 186 rations were entered in order to generate the required protein and energy outputs.

Figure 4.2: Locally weighted smoothed mean (Lowess) plot of pasture crude protein levels arising from the 18 study herds during the Summer 2000 grazing period

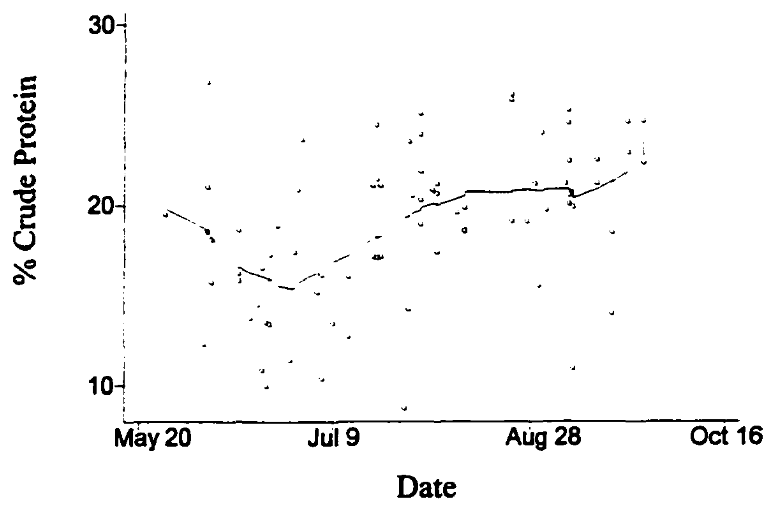


Figure 4.3: Locally weighted smoothed mean (Lowess) plot of 18 herd MUN levels during the Summer 2000 grazing period.

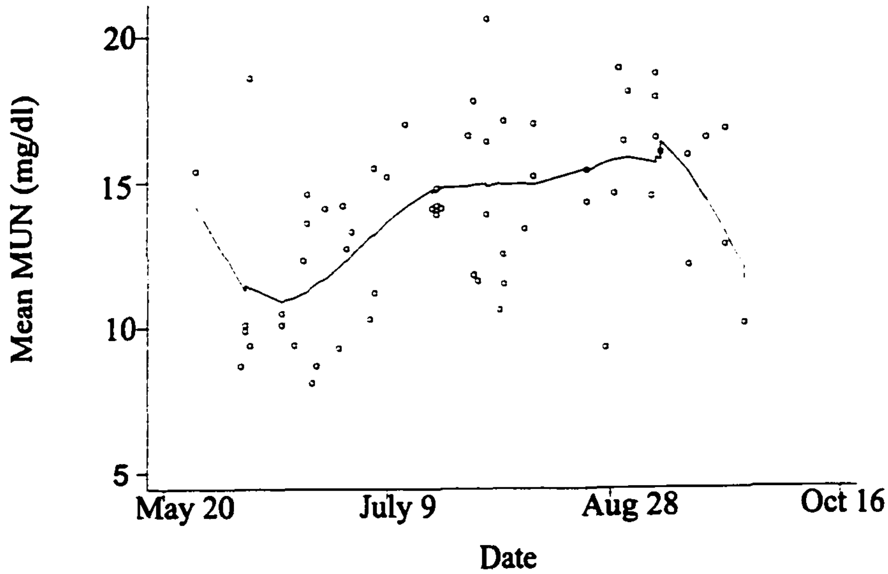


Table 4.4: Mean pasture crude protein (CP), soluble protein (SP) and acid detergent fiber (ADF) and standard deviation (SD), broken down into three geographical zones from 18 herds during the Summer 2000 grazing period.

Component	Western PEI	Central PEI	Eastern PEI	Significance
	μ (SD)	μ (SD)	μ (SD)	
CP (%)	17.99 (4.12)	19.81 (3.62)	18.66 (5.14)	.3286
SP (% of CP)	30.73 (4.47)	32.74 (5.29)	32.15 (4.56)	.3623
ADF (%)	26.70 (3.81)	26.70 (2.93)	28.43 (3.81)	.1824

Table 4.5 ANOVA analysis summary: over all effect of grazing management and sample date on pasture crude protein (CP), soluble protein (SP) and acid detergent fiber (ADF).

Component	Analysis	Treatment	Significance
CP (%)	One way	Grazing management	.4174
		Sample date	.0020
	Two way	Grazing management	.2854
		Sample date	.0031
		Grazing management * sample date	.7634
SP (% CP)	One way	Grazing management	.8834
		Sample date	.6961
	Two way	Grazing management	.8564
		Sample date	.7380
		Grazing management * sample date	.6948
ADF (%)	One way	Grazing management	.9031
		Sample date	.1504
	Two way	Grazing management	.7432
		Sample date	.1376
		Grazing management * sample date	.6377

The estimate of the minimal pasture availability throughout the study was listed (Appendix Q). The visit column represents the minimal amount of dry matter that was available on the visit day and the Rq column represents the herd dry matter requirements multiplied by two because if the available dry matter forage mass was 200 % that of the herd requirements, the pasture was deemed as being able to meet the herd pasture dry matter requirements (12). In all instances the forage mass availability was sufficient and in many cases the availability was 10 - 20 times what was required.

The individual herd milk production estimates representing the top producing animals at 50, 120 and 200 days in milk were tabulated (Appendix R).

4.3.4. Energy and protein levels in the various rations

Protein and energy delivery during early, mid- and late lactation for IGM and EGM herds is summarized in Table 4.6. The PDE interquartile ranges (IQR) were similar across stage of lactation categories with the exception of late lactation IGM cows which had a smaller IQR. In general, the PDE 25 th and 75 th percentiles were lower in EGM herds. The EDE interquartile ranges varied between IGM and EGM herds and also between stage of lactation categories. The overall PER values increased with the stage of lactation.

Table 4.6: Ration energy and protein status for animals 50, 120, and 200 days in milk generated from the eighteen pasture herds enrolled in the study.

Grazing management	Parameter	DIM [a] 50			DIM [a] 120			DIM [a] 200		
		Mean	25 th p	75 th p	Mean	25 th p	75 th p	Mean	25 th p	75 th p
IGM [b]	Protein D\E [c]	0.36	0	0.8	0.28	0	0.8	0.33	0.2	0.5
	Energy D\E [d]	2.71	1.19	4.33	0.78	-0.29	2.06	1.88	2.54	1.07
	PER [e]	1.02	0.94	1.13	1.06	1.04	1.12	1.04	1.00	1.13
EGM [f]	Protein D\E [c]	0.17	-0.3	0.6	0.12	-0.3	0.6	0.30	-0.3	0.7
	Energy D\E [d]	2.80	1.51	4.14	1.60	0.42	2.54	1.69	0.05	2.87
	PER [e]	0.98	0.86	1.06	0.99	0.87	1.09	1.04	0.93	1.13
Overall	Protein D\E [c]	0.26	-0.11	0.76	0.19	-0.2	0.64	0.31	0.00	0.74
	Energy D\E [d]	2.75	1.32	4.14	1.21	0.25	2.42	1.76	0.53	2.63
	PER [e]	1.00	0.88	1.08	1.02	0.92	1.12	1.04	0.96	1.13

[a] Days in milk
[b] Intensive grazing manager
[c] Protein Deficit/ Excess (kg d^{-1})
[d] Energy Deficit/ Excess (M cal d^{-1})
[e] Protein-energy ratio
[f] Extensive grazing manager

Descriptive statistics (mean, 25 th percentile and 75 th percentile) pertaining to milk yield, PER, EDE, PDE and MUN values arising from IGM and EGM herds were listed (Table 4.7). The distribution of the summer 2000 PERs from individual IGM and EGM herds was represented graphically (Figure 4.4). There was a greater proportion of IGM herds with PER greater than 1 when compared to EGM. ($P < .001$). These were herds in which the protein supplied by the ration (as a proportion of the requirements) was higher relative to the amount of energy supplied (as a proportion of the requirements).

Correlations between EDE, PDE and PER were calculated. The PDE and PER had the strongest corrrelation (0.91) The weakest correlation was between PER and EDE (-0.02). The PDE and EDE had a correlation coefficient equal to 0.39.

Multilevel model 1, which had PDE as a dependent variable and stage of lactation and grazing management as independent variables was tabulated (Table 4.8). Assessment of all pairwise interactions from this model demonstrated no significant interaction terms. Stage of lactation and grazing management did not have a significant effect on PDE levels.

Multilevel model 2 (Table 4.9) summarizes the effects of stage of lactation and grazing management on EDE. Assessment of all pairwise interactions from this model demonstrated no significant interaction terms. Stage of lactation had a significant effect on EDE levels whereas grazing management did not. When early lactation EDE levels were utilized as a base line comparison, mid- and late lactation EDE levels were significantly different from the early lactation EDE levels. The predicted EDE were illustrated (Figure 4.5).

Table 4.7: Continuous variable descriptive statistics pertaining to intensive grazing management (IGM), extensive grazing management (EGM) herds.

Continuous variable	EGM			IGM			Overall		
	Mean	25th p[a]	75th p[b]	Mean	25th p[a]	75th p[b]	Mean	25th p[a]	75th p[b]
Milk yield (kg day $^{-1}$)	28.37	21.6	34.4	27.6	20.6	33.0	27.79	21.2	33.6
PER [c]	1.02	0.91	1.12	1.04	1.01	1.12	1.03	0.93	1.12
EDE [d] (M cal d $^{-1}$)	1.87	0.42	3.14	1.75	1.06	2.56	1.82	0.65	2.87
PDE [e] (kg d $^{-1}$)	0.23	-0.20	0.70	0.32	0.0	0.60	0.27	-0.10	0.7
MUN (mg dl $^{-1}$)	13.67	10.75	16.3	14.92	12.2	17.7	14.22	11.4	17.0

[a] 25th percentile
[b] 75th percentile
[c] Protein-energy ratio
[d] Energy Deficit/ Excess
[e] Protein Deficit/ Excess

Figure 4.4: Distribution of energy protein ratios (PER) on intensive and extensive grazing management herds.

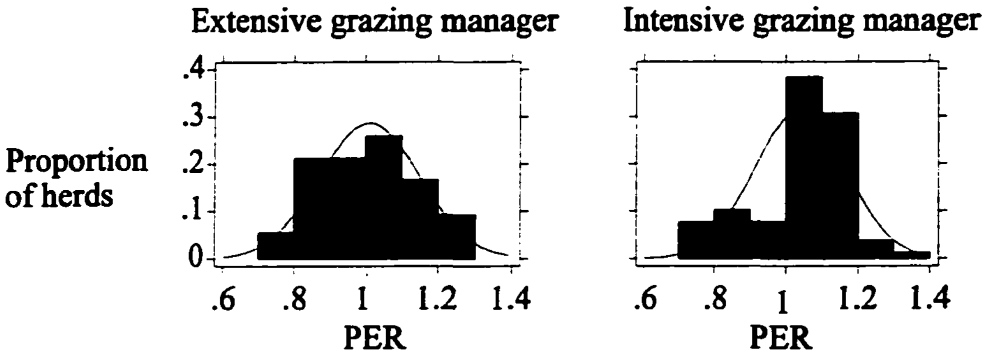


Table 4.8: Multiple level model 1: the effects of stage of lactation, grazing management and month (June -September) on the protein deficit /excess (PDE) delivered in 18 herds by 186 rations.

Effects	Variable	β	Standard Error (β)	P value
Fixed	mid- lactation	-0.124	0.048	
	late lactation	-0.056	0.048	.360
	IGM	0.099	0.121	.413
	Constant	0.149	0.127	

Random	Variable	Variance	Standard Error (variance)	%
	Month	0.195	0.040	73
	herd	0.072	0.009	27

Table 4.9: Multiple level model 2: the effects of stage of lactation, grazing management and month on the energy deficit/excess (EDE) delivered in 18 herds by 186 rations.

Effects	Variable	β	Standard Error (β)	P value
Fixed	mid- lactation	-1.530	0.204	
	late lactation	-0.934	0.204	<.001
	IGM	-0.272	0.464	.555
	Constant	2.933	0.323	

Random	Variable	Variance	Standard Error (variance)	%
	Month	2.816	0.586	68.6
	Herd	1.288	0.164	31.4

4.3.5 MUN

Intensive grazing management herds had higher average MUN values (14.92 mg/dl) than EGM herds (13.68 mg/dl) ($p<0.001$). Monthly mean MUN values for both IGM and EGM herds are presented in Figure 4.6. Graphically, the elevation in MUN in the IGM herds is consistent over all study months. Multiple comparisons among monthly means was not conducted because the power of the study was not sufficient at that level. The monthly average MUN values corresponding to early, mid- and late lactation classification for IGM and EGM herds are presented in Figures 4.7 and 4.8, respectively. Graphically, the mid-lactation mean MUN values are highest for all visits, with the exception of the June test in EGM herds. Again, multiple comparisons among monthly means and stage of lactation was not conducted, because the power of the study was not sufficient at that level.

Multilevel model analysis (Table 4.10) was performed in order to assess the significance of stage of lactation, milk production, grazing management and the PER on MUN levels. Two models were created to describe factors which had significant effects on MUN levels. Multilevel model 4 included the presence of ryegrass as a predictor of MUN, whereas multilevel model 3 did not. Grazing management, stage of lactation, PER, milk yield and the presence of ryegrass had a significant effect on MUN levels. Assessment of all pairwise interactions from both models demonstrated that there was significant interaction between grazing management and ryegrass in model 4.

Figure 4.5: Graphical representation of predicted energy status in EGM herds using early lactation as the baseline.

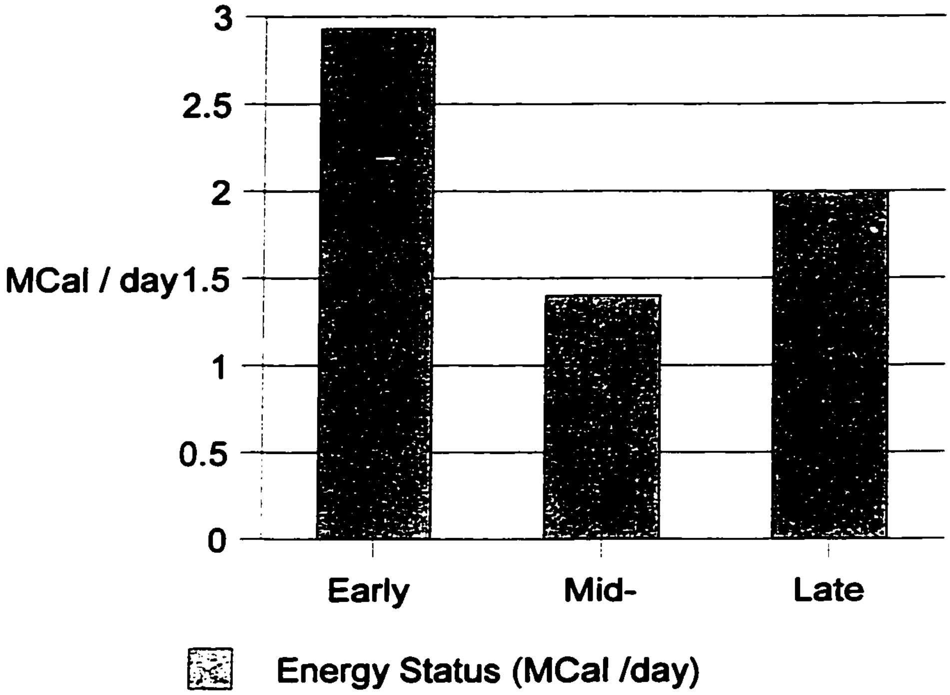


Figure 4.6: Monthly average MUN mg dl $^{-1}$ values of intensive and extensive grazing managers

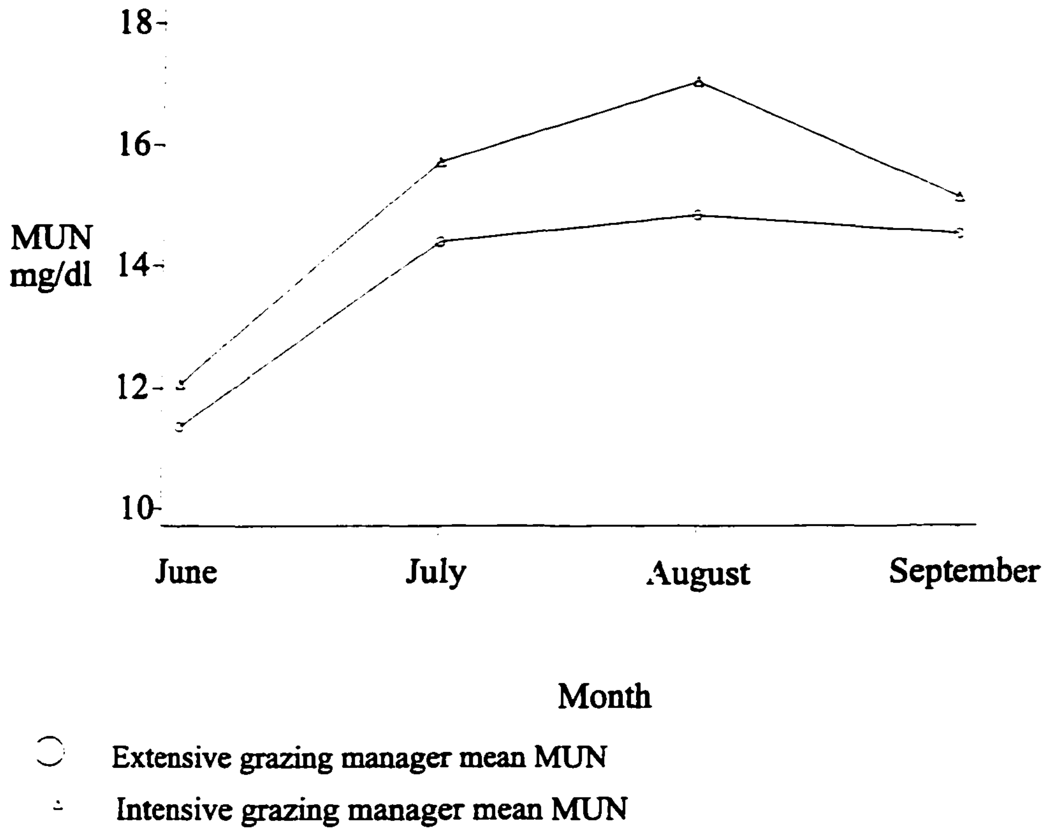


Figure 4.7: Monthly mean milk urea nitrogen (MUN) values by days in milk (DIM) category for animals on intensively managed pastures.

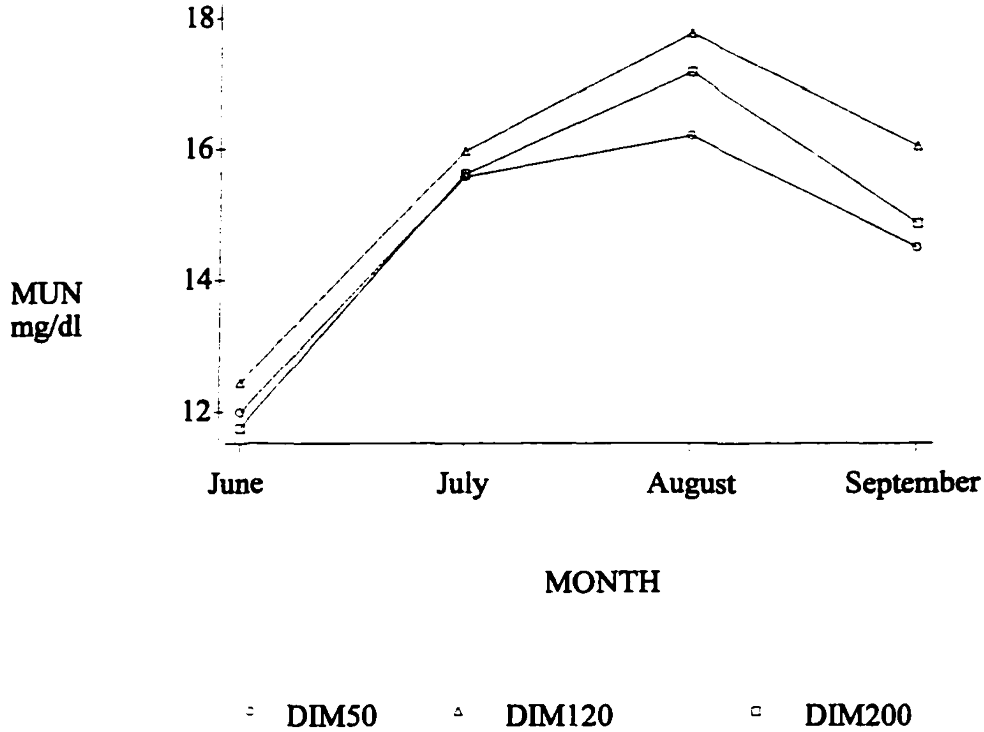


Figure 4.8: Monthly mean MUN values for early, mid and late lactation animals on extensively managed herds

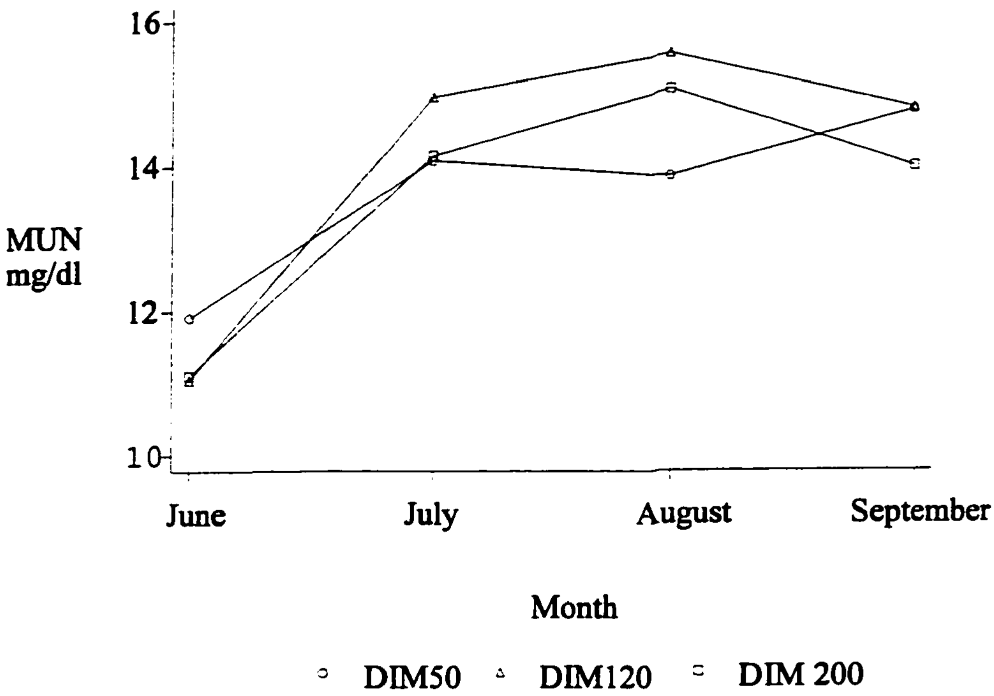


Table 4.10: Multi level model 3, the effects of the protein-energy ratio (PER), stage of lactation, milk yield and grazing management on MUN levels.
Multi level model 4: The effects of the protein-energy ratio (PER), stage of lactation, milk yield, grazing management and ryegrass (RYE) on MUN levels.

		Model 3			Model 4		
Effects	Variable	β	Standard Error	P value	β	Standard Error	P value
Fixed	mid- lactation	0.787	0.250		0.738	0.242	
	late lactation	0.500	0.261	0.006	0.484	0.253	0.009
	milk yield	.032	.011	0.004	0.028	0.011	0.007
	IGM [a]	1.070	0.169	<0.001	0.609	0.180	0.001
	Ryegrass	N/A	N/A	N/A	1.631	0.301	<0.001
	IGM * RYE	N/A	N/A	N/A	1.664	0.420	<0.001
	PER	5.920	.632	<0.001	4.824	0.620	<0.001
	Constant	6.301	.800		7.606	0.784	
Effects	Variable MLM 3	Variance MLM 3	Standard Error (variance)	%	Variance MLM 4	Standard Error (variance)	%
Random	Herd	0.000	0.000	0	0.000	0.000	0
	Cow	6.908	0.964	44.9	7.136	0.985	49.6
	Visit	8.497	1.038	55.1	7.264	1.042	50.4

[a] Intensive grazing management

Table 4.10: Multi level model 3, the effects of the protein-energy ratio (PER), stage of lactation, milk yield and grazing management on MUN levels.
Multi level model 4: The effects of the protein-energy ratio (PER), stage of lactation, milk yield, grazing management and ryegrass (RYE) on MUN levels.

		Model 3			Model 4		
Effects	Variable	β	Standard Error	P value	β	Standard Error	P value
[illegible]	[illegible]		[illegible]				
	late lactation	0.500	0.261	0.006	0.484	0.253	0.029

The relative effect of each continuous variable coefficient on MUN levels was listed (Table 4.11). Despite the magnitude of the coefficient of the PER, it only has a relative effect of 1 mg dl $^{-1}$ whereas milk yield had a much smaller coefficient but had a relative effect that was similar to PER.

4.4 Discussion

4.4.1 Herd selection

The initial goal of having IGM and EGM equally represented in the three geographical zones was not achieved. The IGM were over-represented in central PEI and under-represented in western PEI The significance of the mis-classification is discussed in the next section.

4.4.2 Herd Visit

4.4.2.1 Geographic zones (regions)

Producers reported during initial farm visits that eastern PEI was often two weeks ahead of western PEI in terms of crop growth. To evaluate potential environmental confounders, three subjective geographic zones were created: eastern, central and western. These zones allowed assessment of the effects of geographic location on pasture composition. One-way

Table 4.11: Relative effect of independent continuous variables on MUN predictions arising from multilevel model (MLM) 3 and 4.

		MLM 3		MLM 4	
Variable	IQR	Coefficient	Relative effect on MUN	Coefficient	Relative effect on MUN
milk yield (Kg day $^{-1}$)	22.9	0.032	0.74	0.028	0.64
PER	0.2	5.92	1.18	4.82	0.96

ANOVA indicated that geographic zones had no significant effect on pasture CP, SP and ADF levels. On the basis of these findings, all locations were later pooled for further analysis. This re-categorizing of three zones into one eliminated any impact of the initial grazing management mis-classifications because the overall grazing management distribution was 10 EGM and 8 IGM herds.

4.4.2.2 Grazing management

In this study, grazing management had no significant effect on forage composition. These findings are similar to those of Ortega *et al.* (16). Their study looked at continuous and short duration grazing systems under various stocking densities in Corpus Christi, Texas, between October 1987 and July 1989. Forage samples, collected from esophageally fistulated steers, were similar between grazing managements and stocking densities. Popp *et al.* (17) assessed the effects of grazing system, stocking rate and season on diet quality in steers in Manitoba. Over a three year period, neither grazing management nor stocking rate affected CP or ADF content of grazed herbage.

Other investigations have disagreed with our observations. Mayne *et al.* (18;19) found that grazing management had a significant effect on pasture CP levels. Undergrazed pastures allowed for the accumulation of live stems and dead material. This phenomenon is more often observed in continually grazed swards. Mosquera- Losada's *et al.* (7) work in Spain assessed the effects of grazing pressures on sward quality. They found that grazing management affected pasture CP. Higher stocking densities increased the quality of the forage. The ADF was not affected by increases in stocking density. They believe that short regrowth intervals and high grazing intensity increased the protein content of the pasture as plants are kept in a more immature state (7).

Published results are conflicting. The initial premise of this study was that grazing management would have a significant effect on pasture CP. Despite grazing management classification, our inability to detect significant differences in herbage composition could be due in part to EGM grazing pressure which could have maintained elevated forage CP levels. Perhaps a continuous variable such as stocking density or utilizing the GMI as a continuous variable would have been better at assessing the relationship between grazing management and nutrient components as opposed to the dichotomous IGM/EGM classification.

4.4.2.3 Monthly and yearly fluctuations

Dietary CP significantly varied over the grazing season in this study and others. Post flowering plants have lower levels of CP. This is reflected as higher CP values in the spring and lower values in the summer (7). In Texas, CP values were significantly higher in the spring and summer compared to fall and winter (16). Popp *et al.* (17) found seasonal declines in grazed herbage CP for all individual grazing treatments with the exception of lightly stocked rotational grazed pastures during one year of his study. They associated these seasonal changes in CP with herbage maturity.

Environmental conditions also have an effect on pasture growth. Ortega *et al.* (16), attributed the decrease in forage quality between year 1 and year 2 of their study to reduced precipitation during the second year of the investigation, because CP levels appeared to parallel precipitation levels. Mosquera-Lasoda (7) found that average pasture CP levels in Spain were higher in the summer of 1999 when compared to the two previous summers. They also attributed this difference to wetter growing conditions which promoted growth. Ortega *et al.* (16) found that for dietary CP there was interaction between season and grazing systems and between season and stocking rates. In general, pasture CP was greater under continuous grazing when compared to short duration grazing, with the exception of the spring period during year one. Crude protein values were greater under heavy stocking rates during most seasons except winter. Our results disagreed with Ortega's *et al.* (16). We were not able to find significant interaction for CP, SP and ADF between grazing management and season. The lack of significance may have been partially due to the small sample size and other grazing factors described above. Growing conditions during the summer 2000 grazing period may have contributed to the inability of this study to detect significant differences between the two grazing management practices. In other words, if pastures had been stressed by drought or other stressful conditions, a significant difference could have been detected between IGM and EGM herds.

The pooled pasture percent CP nidus occurred in late June (Figure 4.2), after which the pasture percent CP values continued to increase until late September. The early onset of the herbage CP nidus was surprising and is likely associated with the reproductive growth phase of the pasture plants. The increase in percent CP levels as the summer progressed was unexpected. It is speculated that the observed pasture CP pattern could be due to rain fall and climatic conditions which promoted grass growth during the late summer months.

4.4.3 Ration evaluation

4.4.3.1 Assumption and estimates

During farm visits, farmers estimated the amount of concentrates and forage fed to top producing cows in each stage of lactation group. Consequently, milk production estimates for each stage of lactation group were based on the production values above and including the 50^{th} percentile, with all heifers being excluded from the calculation. The initial weights and BCS changes were assumed to be the same for all cows in all herds throughout the lactation. This assumption will not hold true in all instances but in a large scale observational study, individual BCS was not a practical option.

Pasture NE_l equations may have over estimated the ryegrass NE_l value. The impact of this overestimation will be discussed in section 4.4.4.

Ration evaluation was based on actual animal performance. This approach is somewhat unorthodox. However, our goal was to estimate the dietary protein and energy requirement based on actual animal performance and diet consumed as opposed to production goals which is how rations are traditionally balanced. The difference between predicted dry matter intakes, based on actual milk production and components, and known amounts of feedstuffs ingested were utilized to estimate forage intakes. In less than 1% of the rations balanced, the recorded amount of concentrate resulted in the forage proportion of the ration dropping below 40%. The researchers recognized that feeding this amount of concentrate feeding was harmful and, therefore unlikely. In these few instances, the information was used as collected. In a large scale observational study such as this, the impact of minor errors in diet composition on a small number of farms is minimal compared to the risks associated with making arbitrary decisions about the exclusion of some data.

4.4.3.2 Energy and protein excess / deficit

Spartan© output generated total energy intake, energy requirements, EDE, total protein intake, protein requirements and PDE. These variables were generated for early, mid- and late lactation animals, based on information gathered from each individual farm visit. From these parameters, the PER was computed. The PER is a measure of excess or deficit of protein relative to energy. The PER is equal to an animal's energy and protein requirements ratio divided by the energy and protein delivery ratio of the ration. This ratio was created based on the work of Oltner and Wiktorsson (4) who found that the variation in the total amount of ingested protein had only a slight effect on MUN levels when the ratio between protein intake and energy intake were held constant.

If the ration protein and energy ratio are equal to the required energy and protein ratio the PER equals one. If the PER was greater than one, the ration could have been relatively energy deficient and /or protein abundant. An PER less than 1 could have resulted from a ration that was relatively abundant in energy and /or protein deficient. The following examples will illustrate how an animal's protein and energy requirements and intake influence the PER.

If a given animal required 3 units of energy and 1 unit of protein but only received 2 units of energy and 1 unit of protein the PER would equal (3/1) / (2/1) = 1.5. Alternatively if this same animal required 3 units of energy and 1 unit of protein and received 3 units of energy and 1.5 units of protein the PER would equal (3/1) / (3/1.5) = 1.5

Even though this ratio was generated from energy and protein quotients, the PDE was highly correlated with the PER whereas the EDE was poorly correlated with the PER. The extreme differences in the correlation between EDE and PDE with PER may be explained in part by the different response to increases in dietary protein and energy. If dietary energy is increased and protein remains constant, production should increase accordingly (14), resulting in little change in EDE but a reduction in the PDE (protein requirements have increased with an increase in production) and hence a reduction in the PER. Because milk production is driven by dietary energy (5), increases in dietary protein lead to minimal changes in production. Because production is unchanged, requirements stay the same and therefore the PDE increases as does the PER. This results in a strong correlation between PDE and PER. The correlation between energy intake and production can thereby explain in part why the EDE was poorly correlated with PER.

4.4.3.3 Dietary energy and protein balance

The PER, PDE and EDE descriptive statistics were not remarkable. When compared to EGM herds, IGM herds had a greater proportion of PER greater than 1 ($p < .001$).

Multi level model analysis indicated that neither stage of lactation nor grazing management had a significant effect on PDE levels. The EDE levels were significantly affected by stage of lactation and not by grazing management. When compared to early lactation, EDE levels mid- and late lactation animals had significantly lower predicted EDE values. Mid lactation animals had the lowest predicted EDE values. Body condition score assumptions must be included in the interpretation of the EDE model predictions. During early lactation, animals are estimated to be utilizing .7 kg per day of their own body reserves to meet production requirements (equivalent of losing one BCS point over 65 days) and during mid-lactation, animals are gaining .4 kg per day (equivalent of gaining one BCS point over 125 days). If BCS assumptions had not been made, requirements of the animal would have been higher in early lactation and lower in mid- and late lactation, resulting in lower EDE values in early lactation and higher EDE values in mid- and late lactation animals. These BCS score changes are realistic (20) and were therefore included in the model.

4.4.4 MUN

Pasture and pasture supplementation

Pasture intake can have an effect on rumen nitrogen kinetics because temperate pastures high in nitrogen content and degradability can give rise to ammonia which is absorbed through the rumen (2) . It is therefore likely that MUN levels could be affected by pasture quality, as explained in the following discussion.

In ruminants, each diet ingredient has an effect on rumen kinetics and ingredient utilization. Berzaghi *et al.* (2) evaluated nutrient digestion of lactating cows on pasture. They found that nitrogen losses and rumen ammonia levels were lower when pasture was supplemented with corn. He found that 6.4 kg per head of supplemental corn decreased rumen ammonia nitrogen from 22.4 to 17.1 mg dl^{-1}. He also found that intake nitrogen recovered in the duodenum was about 12 % greater when diets were supplemented with corn. Improved nitrogen efficiency arising from energy supplements can be the result of a reduced forage degradation rate, thus decreasing release of nitrogen and reducing ammonia accumulation in the rumen or additional nitrogen being incorporated into microbial protein. Their study showed that the rate of nitrogen degradation was unchanged and the most likely explanation for the improved nitrogen efficiency is that additional nitrogen was being utilized for microbial protein synthesis when available energy was increased in the diet. Kolver *et al.* (21) attempted to synchronize rumen delivery of supplemental carbohydrates with pasture nitrogen in lactating cows. He concluded that synchronization of rumen release of supplemental carbohydrate and pasture nitrogen appeared to improve capture of ruminal nitrogen. These changes were transient and did not change the nitrogen status of the dairy cow.

The average herd MUN levels (Figure 4.3) had similar patterns when compared to the pasture CP levels during the summer 2000 grazing period (Figure 4.2). Milk urea nitrogen levels are reflective of the entire ration. It is more appropriate to examine the entire ration rather then attempt to derive associations between an individual ration component, such as pasture CP, and MUN levels. Because pasture supplementation can have an effect on nitrogen utilization, it is essential to evaluate the effects of protein and energy delivery during the grazing period .

Milk urea nitrogen predictions based only on individual EDE or PDE levels only partially reflect rumen ammonia dynamics. The PER represents the protein and energy requirements relative to protein and energy delivery. When the PER is high, MUN values are expected to be high. Visual assessment of Figure 4.4 indicated that IGM herds had a higher proportion of PER greater than 1 compared to EGM herds. The mean IGM PER was greater ($p < .001$) than the mean EGM PER (1.04 and 1.02 respectively). Based on these PER values, we would expect MUN levels to be greater for IGM herds. The overall mean MUN in this study was 13.7 and 14.9 for EGM and IGM herds respectively. The difference between these two means was significantly different ($p < .001$). The PER predictions conform with the significant MUN differences. These findings are supported by Figure 4.6 which shows that MUN levels are consistently higher in IGM herds when compared to EGM herds during the summer 2000 grazing season.

Multi level model assessment

Broderick and Clayton (22) performed an evaluation of animal and nutritional factors which influence MUN concentrations. This evaluation resulted in the following mixed effects model: MUN = - 4.713 + 0.484 (BUN) - 0.175 (parity) + 0.003 (body weight) - 0.101 (Milk yield) + 0.187 (3.5% fat corrected milk yield) - 1.802 (Fat yield) + 0.843 (CP) - 0.059 (CP/NE_l) + 0.007 (Excess N intake [g N day^{-1}]) + 0.103 (dry matter intake) - 0.133 (NE_l Intake) + 0.003 (DIM). In this model, the CP/NE_l has a negative coefficient. It is intriguing that this model contained BUN and a variable that was derived from the division of two other variables included in the model and yet the authors did not report a collinearity problem.

Oultner (23) assessed milk yield, live weight, lactation number and amount and composition of feed given to dairy cows in relation to MUN. His work resulted in the following predictive equation for multiparous cows: MUN (mmol l^{-1}) = 0.23 + .62 (CP / ME). This much simpler model had a positive coefficient but does not take into consideration the animals requirements.

Schepers and Meijer (24) evaluated the utilization of dietary nitrogen by dairy cows utilizing the Dutch DVE (true protein digested in the small intestine)-OEB (Rumen degraded balance) system. They found a 0.80 correlation between rumen degraded protein balance in the rumen and MUN. The balance of true protein in the small intestine and net energy had a small but significant effect on MUN. They described the relationship between nutritional factors and MUN concentrations with the following equation: Ln (MUN) = 1.1396 - .0039 (Net energy balance) + .000216 (true protein digested in the small intestine balance) + .0006634 (rumen degraded protein balance). Roseler *et al.* (25) estimated the effects of dietary protein degradability on plasma and milk urea nitrogen. The following regression (r^2 = .67)describes the relationship between PUN and diet: PUN = 5 + 7.49 (DIP) + 11.96 (UIP) - 0.59 (Mcal). In his study, PUN and MUN were strongly correlated (r = 0.88).

Most of the previously published model results agree with ours in terms of protein having a positive influence and energy having a negative influence on MUN levels. The advantage of the models in the present study is that they account for seasonal changes and assess the importance of grazing management, stage of lactation, milk production, PER and presence of ryegrass.

In this study, the multilevel model 3, which excludes ryegrass from the model, revealed that the PER, stage of lactation and grazing management had a significant effect on MUN predictions. The importance of the protein-energy ratio is supported by Oltner and Wiktorsson (4). The magnitude of the PER coefficient is not proportional to its relative effect on MUN predictions. The narrow IQR resulted in MUN changing by .964 mg dl^{-1} as the PER rose from the 25^{th} to 75^{th} percentile. This reveals that the PER was not as important a predictor of MUN as the magnitude of the coefficient would have lead us to believe. On the other hand, the relatively small milk yield coefficient (0.032) led to a 0.641 mg dl^{-1} change in MUN over its IQR implying that milk yield also played a role in predicting MUN, despite the relatively small coefficient.

Stage of lactation was also a significant predictor of MUN. The model predicts that MUN levels will be significantly higher in mid- and late lactation cows when compared to early lactation cows. It was clearly demonstrated (Figure 4.7) that IGM mid- and late lactation cows have larger MUN values when compared to early lactation MUN values. This pattern only holds true during the month of August in EGM herds. The EDE and PDE analysis demonstrated that only stage of lactation had a significant effect on EDE levels. The EDE model predicted that energy levels would be at their lowest during mid-lactation when compared to early lactation animals. Low energy intake levels are associated with elevated MUN levels. The low predicted energy intake levels in mid-lactation animals could explain in part the observed high MUN levels observed in this same group of animals.

Inclusion of ryegrass, as a dichotomous variable, in multilevel model 4 resulted in important coefficient changes (Table 4.10). The PER coefficient decreased from 5.92 to 4.82 and there was a significant interaction between IGM herds and the presence of ryegrass. Ryegrass resulted in MUN levels in EGM herds that were 1.6 mg dl^{-1} higher ($p=.001$) than those in EGM herds that did not feed ryegrass. In IGM herds, feeding ryegrass increased MUN levels by 3.3 mg dl^{-1}. Since IGM herds also generally had higher MUN values the EGM herds, an IGM herd feeding ryegrass would be expected to have

MUN levels 3.9 mg dl^{-1} higher (p =.001) then EGM herds that did not utilize ryegrass.

The importance of ryegrass as a predictor of MUN is intriguing because comparisons of ryegrass and cool season grass components sampled on the same day from the same farm showed no significantly different nutritive analysis (Table 4.3). Because laboratory analyses indicated that both grasses have similar CP, SP and ADF profiles, the reason behind the ryegrass effect on MUN is unknown.

Work done by Hume (26) showed that ryegrass inflorescence have relatively high nitrogen content. However, their greater cell wall content was associated with a relatively low digestibility three months after seeding. A review paper written by Westwood (27) stated that ryegrass and clover pastures frequently contain low levels of readily fermentable carbohydrate, in the range of 5 to 20 % of dry matter. Optimal fermentable carbohydrate levels for lactating cows are in the 30 to 35 % range (27).

Routine PEISFTL analysis do not detect differences in carbohydrate digestibility. This may partially explain why ryegrass and non-ryegrass cool season grasses had similar compositional analyses.

In our study, only one equation was utilized to calculate pasture NE_l values based on ADF values. Ryegrass has been reported to have lower cell wall digestibility (26;27). Ryegrass NE_l values may be over estimated because ADF was unable to account for subtle differences in carbohydrate digestibility. If specific ryegrass NE_l equations would had been available, perhaps we could have better explained the biology behind the observed increases in MUN levels when rye grass was ingested.

4.5 Conclusion

In this study, grazing management and geographical zones did not have a significant effect on pasture components. However season did have a significant effect on pasture CP levels, with protein levels increasing throughout the grazing season. Ideal growing conditions may have been associated with the unexpectedly high pasture CP levels observed in this study in the late summer and early fall. The grazing pressure differences between IGM and EGM herds may not have been large enough, thereby making it difficult to establish statistically significant differences between IGM and EGM pasture components.

Stage of lactation had a significant effect on EDE levels ($p<.001$). Cows in mid- or late lactation had significantly lower EDE levels (Table 4.9) when compared to early lactation EDE levels. Mid- lactation animals were predicted to have the lowest EDE levels when early lactation cows were utilized as the base line comparison. Stage of lactation had no significant effect on PDE levels. Grazing management had no significant effect on PDE or EDE levels.

Multilevel model analysis identified stage of lactation, grazing management, milk yield and the PER as significant predictors of MUN. Increased MUN levels during mid-lactation can partially be explained by low EDE levels predicted for the same stage of lactation period.

Inclusion of ryegrass in the model produced a significant interaction term between ryegrass and IGM. Predicted MUN values were 3.9 units higher on IGM herds where ryegrass was present when compared to EGM herds where ryegrass was absent.

Based on these findings, particular importance must be made to the carbohydrate levels of a ration when ryegrass is being ingested, as the literature suggests that carbohydrates in ryegrass are not readily available. A better understanding of ryegrass structure and ruminal degradation would be helpful and would allow us to make sound nutritional recommendations that could result in improved nitrogen efficiency.

4.6 References

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Chapter 5

Observational study assessing the significance of nutritional and management factors associated with milk urea nitrogen levels during the non grazing season

5.1 Introduction

Under experimental settings, the effect of dietary protein and energy on PUN and MUN levels has been recognized (1). Experimentally, it has also been demonstrated that the protein-energy relationship of a ration was the main dietary factor that affected MUN levels (2;3). Models resulting from Oltner *et al.* (3) had r^2 values that ranged between 0.31 and 0.33. Broderick and Clayton (4) evaluated animal and nutritional factors that influenced MUN concentrations. Their study identified a mixed effect model with an r^2 = 0.875. In another study (5) the suitability of MUN levels as a monitor of protein utilization was investigated with data that originated from 11 feed trials. This work was evaluated at both the cow and herd level. The fixed effects (nutritional factors) in this model explained 69 % of the variation in the natural logarithm of the MUN concentration.

All of the above research was done under controlled experimental situations. The association between dietary protein and energy levels on MUN levels at the herd or cow group level, under commercial conditions, has yet to be evaluated.

The ration protein-energy relationship was found to be a significant predictor of MUN (2). The significance of the protein-energy requirements in relation to the energy and protein supplied has not been investigated. Also not yet investigated are the impacts on MUN levels of protein and energy fractions, feeding frequency, ration delivery and feed additives.

Feed delivery can have an effect on rumen dynamics. Certain feeding management practices can result in fluctuations in the diurnal patterns of rumen metabolites and pH, resulting in reduced rumen microbial growth and decreased fermentation efficiency (6). Animals ingesting a total mixed ration (TMR) should be ingesting a constant forage-to-concentrate ratio, reducing diurnal fluctuations. Conversely, forage-to-concentrate ratio will not be constant when concentrates are fed separately under a component ration (CR) feeding system. Frequency of concentrate feeding on CR herds may also affect rumen diurnal fluctuations.

Feed additives can also influence the rumen environment, which can have an effect on energy and protein utilization. The presence of ionophores in the rumen results in a shift of the rumen microbial population, which leads to increased energy efficiency, improved nitrogen utilization and other effects, such as decreased bloat and decreased lactic acidosis (7). Because ionophores influence protein and energy metabolism, their effect on MUN levels needs to be investigated.

The main objective of this study was to assess the impact of nutritional factors on MUN levels during the non-pastured period. This objective complements the work which assessed the seasonal variations in MUN in herds grazing intensively and extensively managed pastures (Chapter 4). In order to meet the main objective, the amount of variation in test-day MUN, which could be explained by the protein-energy ratio of the diet, was measured. The impact of protein and energy fractions, feed delivery systems, feeding frequencies and ionophore utilization were also assessed in order to achieve the main objective.

5.2 Materials and Methods

5.2.1 Herd selection and classification

Initial herd selection was based on grazing management and was described in Chapter 2. Ninety-two dairy herds, eighty-three from PEI and nine from Nova Scotia, were classified according to their winter feed delivery system in the fall of 1999. Herds feeding only TMR or herds feeding a TMR with supplementation by a computer feeder or grain in the parlor, were defined as TMR. Herds utilizing a component feed delivery system were defined as CR.

5.2.2 Farm visits and data collection

Between October 1999 and January 2001, all herds were visited twice and contacted once by telephone. The first visit took place between October 29, 1999 and January, 15 2000 in

PEI and between December 4 and December 30, 1999 in NS. During this visit, the initial farm survey (Appendix C-1) was completed. The first objective of this questionnaire was to capture basic herd management information. The second objective was to identify and quantify, on a daily basis, the various feedstuffs that were being fed at 50, 120 and 200 days in milk. Estimates of feed intake were made for the top production levels in each of the three stage of lactation groupings. Forage and grain samples were collected during the visit. Stored forages sampling protocols were described in Chapter 2.

The Spring 2000 nutritional data were collected between March 15, 2000 and May 3, 2000 by telephone for all PEI herds and in person between April 10 and May 23, 2000 in NS. The Spring 2000 nutritional questionnaire (Appendix C-2) captured information on quantity and quality of feeds fed, grain processing, and ionophore utilization. Individual herds were revisited when researchers determined that they did not have a forage analysis that represented the forage being fed at the time of the telephone interview.

The second farm visit took place between October 20, 2000 and January 15, 2001 on eighty PEI study herds and between January 15, 2001 and February 28, 2001 on the 9 NS study herds. Due to time constraints, three PEI herds were not visited during this sampling period. Herds were visited within 48 hours of an ADLIC test. The final farm visit questionnaire (Appendix G) captured detailed nutritional and feeding information. Feedstuff samples were collected in a similar manner to the previous year.

5.2.3 Feed composition data

All feed samples were submitted to the PEISFTL. Forage classification, feed analyses and procedures performed by the PEISFTL are summarized in Chapter 2. Laboratory results were transferred electronically from the PEISFTL to the Atlantic Veterinary College. Feed stuff composition data were individually validated by comparing data in the master file with the individual feed reports that were received by mail.

5.2.4 Data entry

5.2.4.1 Assumptions and estimates

Each herd visit resulted in individual dairy rations being created for early (DIM 50), mid- (DIM 120) and late lactation (DIM 200) animals. Creation of these rations required, in addition to the feed quantity and compositional data, some additional data that were either available or based on assumptions. For example, body condition score changes taking place throughout lactation and body weights were assumed to be similar on all farms and are described in Chapter 4. Rations were balanced for a second lactation animal. Milk production was estimated from ADLIC data. Milk production and component estimates were calculated for the three lactation stage groups in each of the three sampling periods in each of the individual herds (n = 92). Production data from October 6, 1999 to January 31, 2000, February 2000 to May 15, 2000, and October 15, 2000 to December 29, 2000 were utilized to generate the average milk production and milk components for Fall 1999, Spring 2000 and Fall 2000 sampling periods, respectively. During the farm visits, producers estimated the amount of feed fed to the top-producing animals in each of the three stages of lactation. Hence, all heifers and cows with production levels below the fiftieth percentile were excluded when determining production and component estimates. Early, mid- and late lactation estimates of the top-producing animals in each stage of lactation were based on data from cows in the following stages of lactation: 40 and 60 DIM, 110 and 130 DIM and 190 and 210 DIM. Inclusion of cattle with milk production above the 50 percentile ensured that the milk production estimates would represent the highest production levels in each of the three groups of stage of lactation, the level to which producers typically feed their herd.

5.2.4.2 Ration balancing

Spartan© and CPM© dry matter intake predictions were based on parity, body weight, stage of lactation, milk production and milk components. Rations were balanced for a second lactation animal, weighing 630 kg at calving. Milk production levels and milk components were determined from the herd's ADLIC data (section 5.2.4.1.). Known amounts of concentrates were entered in the ration evaluator program. Forage intake was assumed to make up the remaining portion of predicted dry matter intake. When more than one forage was included in the diet, producers estimated the proportion of each forage in the ration relative to the total amount of forage fed. Forage estimates were made on an as-fed basis (AF), whereas the ration was balanced on a dry matter (DM) basis. An example calculations which demonstrates how the ration was balanced when more than one forage was fed follows. In this example the animal's diet consisted of 5.07 kg (dry matter(DM)) of dairy ration and the remainder of the diet was made up of two forages.

Forage "A" was 85.7 % dry matter and forage "B" was 45.2 % dry matter. On an as fed (AF) basis, 10 % of the forage that was ingested was Forage "A" and the remaining 90 % was forage "B". The animal was predicted to ingest 22.35 kg of dry matter.

Step 1:

Available forage DM intake = Predicted DM intake (all feeds) - Known DM intake (non-forage)

Available forage DM intake = 22.35 kg DM - 5.07 kg DM (dairy ration)

Available forage DM intake = 17.28 kg DM

Step 2:

Ration forage DM = (Forage DM "A"* prop. in diet) + (Forage DM "B"*prop in diet)

Ration forage DM = (.857 *.10 + .452 * .90)

Ration forage DM = .4925

Step 3:

$$\text{Available AF intake} = \frac{\text{Available DM intake}}{\text{Ration forage DM}}$$

Available AF intake = 17.28 kg DM / .4925

Available AF intake = 35.09 kg as fed

Step 4:

Forage "A" in diet AF = Available AF intake * proportion of forage A in diet AF

Forage "A" in diet AF = 35.09 * .10 = 3.51

Forage "B" in diet AF = Available AF intake * proportion of forage "B"in diet AF

Forage "B" in diet AF = 35.09 * .90 = 31.58

Forage "A" DM intake = 3.51 * .857 = 3.01 kg DM

Forage "B" DM intake = 31.58 * .452 = 14.27 kg DM

Total Forage DM intake = 17.27

Total Forage DM required = 17.28

5.2.4.3 Spartan© 2.01

Spartan© 2.01 is a ration evaluator developed at Michigan State University based on the 1989 National Research Council nutritional requirements of dairy cattle. Input values required to operate Spartan© were available from the feed reports generated from the PEISFTL. Forages and grains in the diet were selected from the Spartan© library and edited with available analysis data, to more closely resemble the feeds that were fed. The adjusted CP value, which is equal to the % CP - (% CP * % BP), was entered as the CP value for all ensiled forages.

Commercial rations were entered in a custom product library with the cooperation of four major feed companies who made available confidential product specifications. Spartan© generated output that detailed the energy and protein requirements and the amount of energy and protein available in the various rations being fed. These four variables were utilized to generate the protein-energy ratio (PER). The PER relates the animal's protein and energy requirements to the protein and energy delivered by the ration. Chapter 4 offers an in-depth explanation of how the PER was calculated and how it was affected by changes in protein and/or energy levels. However, in summary, the PER is > 1 when protein excess surpassed energy excess or protein deficiency was less than energy deficiency. The PER was less than one if the relative energy excess exceeded the relative protein excess or a relative energy deficiency was less then the relative protein deficiency. The PER was calculated for each herd visit and for all three groupings of stage of lactation. The PER was utilized as an independent variable to assess the effects of protein and energy levels, relative to the animals requirements, on MUN values in multilevel model analyses.

5.2.4.4. Cornell - University of Pennsylvania - Miner Institute (CPM©) Dairy 1.0

The CPM© Dairy ration evaluator predicts cattle requirements, feed utilization and animal performance (8). Input parameters include CP, BP, SP, NDF, lignin and NDF digestibility. The last two input parameters were not determined by the PEISFTL.

An attempt was made to measure lignin values on 10 % of the forage samples collected during the fall 1999 farm visits. A subset of 23 samples were submitted to a private feed laboratory. Three of the samples were in duplicate. Repeatability of the test results was questionable because the results of one of the duplicate submissions reported 13.53 % and 22.26 % of the NDF being lignin. In-house lignin determination at the Atlantic Veterinary College also produced results with low repeatability, even with lignin determination being performed in duplicate and with a known standard. While the standard results were as expected, the forage duplicate sample results were not consistent. Consequently CPM© library default lignin values were utilized, with the appropriate forage being selected from the CPM© library based on forage species and NDF levels .

In vivo 30 hour digestibility was performed on 22 forage samples at the Nova Scotia Agricultural College. These values were utilized to validate the CPM© library NDF degradation rates. The CPM© Dairy ration evaluator will compute predicted 30 hour digestibilities based on the forage type, NDF values, lignin levels and an assumed rate of passage (3.3 % h^{-1}). These predicted values were compared to the observed values for the 22 samples.

The CPM© dairy ration evaluator output includes estimates of carbohydrate and protein fractions in the diet, expressed as percentages. Carbohydrates were divided into the following fractions: A, B1, B2 and C. Fraction A consisted of sugars and volatile fatty acids. Fraction B1 was composed of starch, pectin and beta glucans. Fractions B2 and C represented available and unavailable fiber, respectively.

Proteins were divided into the following five fractions: A, B1, B2, B3 and C. Fraction A represented non protein nitrogen and B1 represents SP. Fractions B2, B3 and C represented medium degradation, slow degradation and unavailable protein, respectively.

The available metabolizable protein value was equal to the sum of the rumen escape protein and bacterial protein (fraction A, B1, B2 and B3) in kilograms. The total protein of the diet equaled available metabolizable protein plus the "protein C" fraction. CPM© fractions were converted from percentages to actual amounts fed as follows:

Total protein (TP) (g) = metabolizable protein (MP) (g) + C fraction (proportion TP)

MP (g) = TP - TP* C fraction (proportion)

$$TP = \frac{\text{metabolizable protein}}{(1 - \text{C fraction (proportion)})}$$

For example if MP = 543 g and C fraction = 14% of TP

TP (g) = 543 + 0.014*TP
543 = TP -.0.14 TP
543 = 0.86 TP
TP = 543/0.86
TP = 631 g

Kg protein in each fraction =

Total protein in diet (g) * various feed fractions (A, B1, B2, B3 & C) / 1000

Available metabolizable energy is affected by ruminal digestion and passage rates of the carbohydrate fractions. As a result, energy fractions were not as easily categorized as protein fractions. In this study, available metabolizable energy was computed as the sum of carbohydrate fractions A, B1 and B2. The total energy of the diet was the sum of available metabolizable energy and carbohydrate fraction C. The CPM© fractions were converted from percentages to actual amounts fed following a similar conversion equation as was used in the protein calculation:

$$\text{Total energy diet (Mcal d}^{-1}\text{)} = \frac{\text{Metabolizable energy (Mcal d}^{-1}\text{)}}{(1\text{-C fraction (proportion)})}$$

Mcal of energy in each fraction =

Total energy in diet (Mcal) * various feed fractions (A, B1, B2 &C [as a proportion])

The CPM© PER was computed as the metabolizable energy requirement:metabolizable protein requirement ratio divided by the available metabolizable energy:available metabolizable protein ratio

5.2.5 Statistical analysis

Data were collected over two winter feeding periods. The data consisted of an individual record for each visit (n = 1 to 3 per cow) for each cow (n = 13 to 197 per herd), in each herd (n = 92). Each record contained the estimated nutritional requirements for the cow at that visit, the nutrient composition of the diet fed to that cow, some herd management data and the observed MUN level for the cow at the visit. Descriptive statistics were computed using Stata Ver 6 (9). Hierarchical structure (visits within cow within herd) multilevel models were fit using MlwiN (version 1.10) to evaluate the effects of various factors on MUN levels (the dependent variable) and the variance in MUN values at each level of the hierarchy. Separate sets of models were built using the Spartan© and CPM© ration because each ration evaluator produced different parameters.

Independent variables included: PER, stage of lactation groupings, (early, mid- and late) ration delivery (total mixed ration (TMR) vs CR), ionophore utilization and grain feeding frequency. Early, mid- and late satge of lactation groupings were represented by cows 20 to 80, 81 to 160, and greater than 160 days in milk, respectively. Both ration delivery and ionophore utilization were dichotomous variables. The importance of grain feeding frequencies and ionophore utilization was only assessed in the Spartan© models.

Similar models (Spartan© model 1 - 5) were created from the Spartan© ration evaluations. Spartan© model 1 contained the constant. This model acted as a baseline comparison for Spartan© model 2 which contained the constant and the PER. Spartan© model 3 (constant, stage of lactation grouping and feed delivery) served as a baseline comparison for Spartan© model 4 (measured effect of feed additives and feeding frequency) and 5 (measured effect of PER & interaction). Spartan© model 5, containing stage of lactation, feed delivery, PER and relevant two way interaction terms was evaluated in more detail to determine the impact of changes in the predictor variables on MUN levels.

Seven multilevel models (CPM© models 1-7) were created from the CPM© Dairy output in order to evaluate the amount of variation in MUN that could be explained by the various independent variables. Eleven herds were not included in these models because the concentrates fed on the farm originated from a feed company other than Co-op, Shur-Gain or Purina. Only these three feed companies disclosed their product ingredient list which allowed us to enter their products into CPM©. Model 1 (CPM©) contained only stage of lactation groupings and feed delivery as independent variables. Models 2 - 7 (CPM©) contained the same two predictors as CPM© model 1, plus various combinations of nutritional parameters in order to determine which nutritional parameters were best able to account for variations in MUN levels.

5.3 Results

5.3.1 Feed additives, grain feeding frequencies

Table 5.1 summarizes the level of ionophore utilization and grain feeding frequency in the TMR and CR herds during the non-grazing period. There was a larger percentage of TMR herds that utilized ionophores when compared to CR herds. The majority of TMR herds fed the TMR mixture twice per day while a higher proportion of CR herds fed grain four or more times per day.

5.3.2 Energy and protein requirements and availability during the non-grazing periods

Table 5.2 summarizes the protein and energy requirements and estimated amounts provided by the ration as generated by Spartan© and CPM© Dairy for the Fall 1999, Spring 2000 and Fall 2000 sampling periods. The average available CP protein value, estimated by Spartan©, during each sampling period was at least equal or greater than the average daily requirements for the animals in all of the groups of stage of lactation. The average energy delivery, calculated by Spartan©, was close to the animals daily requirement (± 0.1).

In **Table 5.1:** Frequency of feed additive utilization and feeding frequency (FF) on total mixed ration (TMR) and component ration (CR) herds during the winter 2000 confinement period.

Herd categorization	Ionophore present	FF 1 day $^{-1}$	FF 2 day $^{-1}$	FF 3 day $^{-1}$	FF 4 day $^{-1}$	FF > 4 day $^{-1}$
TMR	37 %	20%	52 %	3 %	7 %	14 %
CR	17 %	0 %	34 %	10 %	24 %	32 %

Table 5.2: Protein and energy summary generated from CPM© dairy and Spartan© output for the Fall 99, Spring 2000 and Fall 2000 time periods.

Herd classification	Output origin	Variable	Fall 1999		Spring 2000		Fall 2000	
			Required	Available	Required	Available	Required	Available
TMR Ration	Spartan©	NE_l (Mcal d^{-1})	38.0	38.1	37.9	37.8	37.2	37.1
		Avail. CP (kg d^{-1})	3.7	3.9	3.7	4.0	3.7	3.8
	CPM©	Met energy (MCal d^{-1})	60.9	58.6	60.3	58.2	59.4	58.0
		Met protein (kg d^{-1})	2.4	2.6	2.5	2.3	2.5	2.4
Component Ration	Spartan©	NE_l (MCal d^{-1})	34.2	34.4	34.3	34.3	32.9	33.0
		Avail. CP (kg d^{-1})	3.3	3.5	3.4	3.5	3.2	3.3
	CPM©	Met energy (MCal d^{-1})	55.1	51.8	55.0	52.0	52.4	49.9
		Met protein (kg d^{-1})	2.33	2.08	2.33	2.08	2.23	1.9

The CPM© Dairy outputs estimated that the average dietary metabolizable protein and metabolizable energy were below the animals' daily requirements. Both CPM© and Spartan© provided different assessments of the adequacy of the diets fed.

Summary statistics on the various CPM© dairy protein and energy fractions and the PER generated by Spartan© and CPM© Dairy are listed in Table 5.3. Both mean values and interquartile ranges (IQR) are presented. In general, the IQR ranges were relatively narrow when compared to the mean values, although they were larger for the CPM© fractions than for the overall PER.

Mean MUN values on TMR and CR herds were calculated using Stata version 6.0 (9) (Table 5.4). Both herd categories had similar MUN patterns with mean MUN values peaking during the spring 2000 non-grazing period.

5.3.3 Multilevel models

Variance estimates for CPM© models 1 to 7 were tabulated (Table 5.5). After adjustment for stage of lactation and feed delivery, the PER could only explain 0.5 % of the total variation in MUN. When all of the protein and energy fractions (9 independent variables) were included in the multilevel model, this model explained 5.5 % of the variation in MUN. In general, the nutritional parameters were only able to explain a very small amount

Table 5.3: Summary statistics pertaining to CPM© Dairy protein (P) and energy (C) fractions and Spartan© and CPM© energy and protein ratios (PER).

Program	Variable	Mean	25 th percentile	75 th percentile	Inter-quartile range
Spartan©	PER	1.04	.98	1.11	.13
CPM©	PER	.94	.90	.99	.09
	C:A fraction	9	8	10	2
	C:B1 fraction	46	42	52	10
	C:B2 fraction	32	29	36	7
	C:C fraction	12.5	9	15	6
	P:A fraction	28.4	23	32	9
	P:B1 fraction	8.4	6	11	5
	P:B2 fraction	45	42	50	8
	P:B3 fraction	12	10	14	4
	P:C fraction	6	5	7	2
	C:A Mcal d^{-1}	5.65	4.88	6.41	1.53
	C:B1 Mcal d^{-1}	29.04	24.48	33.85	9.37
	C:B2 Mcal d^{-1}	19.69	17.84	21.49	3.65
	C:C Mcal d^{-1}	7.65	5.76	9.14	3.38
	P:A kg d^{-1}	.664	.526	.750	.224
	P:B1 kg d^{-1}	.196	.126	.266	.140
	P:B2 kg d^{-1}	1.060	.892	1.239	.347
	P:B3 kg d^{-1}	.275	.217	.323	.106
	P:C kg d^{-1}	.134	.108	.152	.044

Table 5.4: Milk urea nitrogen (MUN) descriptive statistics pertaining to total mixed ration (TMR) and component ration (CR) herds for the Fall 99, Spring 2000 and Fall 2000 time periods.

Herd classification	MUN Descriptive statistic	Fall 1999 MUN (mg dl $^{-1}$)	Spring 2000 MUN (mg dl $^{-1}$)	Fall 2000 MUN (mg dl $^{-1}$)
TMR	Mean	10.8	12.1	10.1
	25 thpercentile	8.7	10.0	8.1
	75 thpercentile	12.9	14.2	11.8
CR	Mean	10.0	12.8	10.5
	25 thpercentile	8.2	10.4	8.2
	75 thpercentile	13.0	15.2	12.6

Table 5.5: Variance estimates from CPM© multi level models 1 - 7, based on 10,527 MUN observations from 5,730 cows in 81 dairy herds in Prince Edward Island and Nova Scotia.

		Variance				
Number	Independent variables	Herd	Cow	Visit	Total	% explained [a]
1	1 [b]	2.013	1.817	8.076	11.906	N/A
2	1+ PER [c]	2.040	1.857	7.966	11.863	0.5%
3	1+ total protein kg d^{-1}	1.651	1.783	7.975	11.409	4.0%
4	1+ total energy Mcal d^{-1}	1.572	1.804	7.994	11.370	4.5%
5	1+ protein fractions kg d^{-1}	1.611	1.705	7.978	11.294	5.1%
6	1+ energy fractions Mcal d^{-1}	1.720	1.650	7.979	11.349	4.6%
7	1+ energy + protein fractions	1.720	1.562	7.967	11.249	5.5%

[a] Percent of total variance explained compared to model 1

[b] Multilevel model that contained feed delivery (TMR) and stage of lactation groupings (mid- and late)

[c] Protein-energy ratio

of the total variability in MUN. However, they did explain approximately 14 % of each of the herd and cow level variances (ie: (2.013 - 1.720) / 2.013) and (1.817- 1.562) / 1.817)). Detailed breakdown of the energy and protein fractions added very little to a simple measurement of the total energy and protein fed.

The variance estimates for Spartan© models 1 to 7 were also tabulated (Table 5.6). The PER explained 5.93 % of the variation in MUN when compared to Spartan© model 1 which contained only a constant. The addition of ionophor utilization and feeding frequency could only explain an additional 0.8 % of the residual variation. These two parameters were not significant predictors of MUN and therefore not included in the CPM© models. Model 5 which contained PER, TMR, stage of lactation and significant two way interactions only explained 6.7 % of the total variation but 12.7 % of the herd variation.

Spartan© multilevel model 5 is outlined in Table 5.7. Feeding frequency ($p = .076$) and ionophore utilization ($p=.590$) were dropped as they lacked statistical significance. Interpretation of the Spartan© multilevel model 5 is simplified by assessing the predicted MUN levels changes associated with changes in the significant predictor variables (Table 5.8). Increases in the PER from 0.97 to 1.1 (i.e. across the IQR) resulted in increased MUN values (0.38 to 0.88 mg dl^{-1}) in both TMR and CR herds and in all stages of lactation. The TMR and CR mid-lactation cows were predicted to have the highest MUN levels whereas the late lactation groupings were predicted to have the lowest MUN

Table 5.6: Variance estimates from Spartan© multi level models 1 - 5 based on 13,073 MUN observations from 7,081 cows in 92 dairy herds on Prince Edward Island and Nova Scotia.

		Variance				
Number	Independent variables	Herd	Cow	Visit	Total	% explained
1	Constant	3.254	1.543	7.502	12.299	N/A
2	PER [a]	2.838	1.522	7.210	11.570	5.9% [c]
3	TMR [b], stage of lactation	3.252	1.614	7.333	12.199	.8% [c]
4	TMR[b], stage of lactation, feeding frequency, feed additives	3.298	1.600	7.204	12.102	.8% [d]
5	PER[a], TMR[b], stage of lactation, interactions	2.840	1.507	7.125	11.472	6.7% [c]

[a] Protein-energy Ratio
[b] Total mixed ration
[c] Percent of total variance explained compared to model 1
[d] Percent of total variance explained compared to model 3

Table 5.7: Spartan© model 5: The effects of Spartan© energy and protein estimates, feed delivery and stage of lactation groupings on milk urea nitrogen (MUN) levels.

Effect	Variable	β	β Standard Error	p value
Fixed	Constant	4.629	.599	<.001
	PER	6.326	.509	<.001
	TMR	1.528	.654	.018
	Mid- lactation	2.390	.546	
	Late lactation	-0.068	.550	<.001
	TMR * PER	-1.424	.473	.002
	TMR * Mid- lactation	-0.186	.156	
	TMR * Late lactation	-0.571	.139	<.0001
	PER * Mid- lactation	-1.967	.499	
	PER * Late lactation	0.042	.504	<.001
Effect	**Variable**	**Variance**	**Variance S.E.**	**%**
Random	Herd	2.840	0.431	24.7
	Cow	1.507	0.829	13.2
	Visit	7.125	0.831	62.1

Table 5.8: Summary of predicted MUN changes when the protein-energy ratio (PER) and stage of lactation categories change on total mixed ration (TMR) and component ration (CR) herds.

Herd classification	Stage of lactation	Predicted MUN when PER = .97	Predicted MUN when PER = 1.1	Change associated with PER (.97) to PER (1.1)	Change associated with increases in DIM	
					PER .97	PER 1.11
TMR	Early	10.91	11.55	0.64	N/A	N/A
	Mid-	11.21	11.59	0.38	0.3	0.04
	Late	10.31	10.96	0.65	-0.9	-.63
CR	Early	10.77	11.65	0.88	N/A	N/A
	Mid-	11.25	11.85	0.60	0.5	0.2
	Late	10.74	11.57	0.83	-0.5	-0.3

values. The changes in MUN throughout lactation appeared to be smaller when the PER = 1.1 compared to when the PER = 0.97. Overall, the magnitudes of the effects of stage of lactation, feed delivery (TMR) and PER on MUN values were small.

5.4 Discussion

5.4.1 Nutritional Management

When creating the farm visit surveys, the effect of ionophore utilization was deemed important because it had a known effect on energy metabolism (7). In this study, the presence of an ionophore in the diet did not have a significant effect on MUN values. There was no literature which investigated the effects of ionophore utilization on MUN levels.

Information pertaining to feeding frequency was also collected during farm visits. The effect of certain changes in the rumen environment on MUN levels is unknown. Feeding frequency has an effect on the rumen environment. Literature indicated that when large amounts of concentrates were fed twice daily, the rumen pH drops below 6.0, 2 to 3 hours after each meal. When the rumen pH dropped below 6.0, cellulolysis is reduced (10). Increasing the feeding frequency may reduce the negative effects of intensive concentrate fermentation in the rumen by reducing fluctuations in volatile fatty acids, pH, and ammonia (6). While feeding frequency approached significance ($P = .076$), it was not included in the multilevel models since the effect on MUN was small and would be biologically insignificant. Additionally, the study had adequate size to detect factors that significantly affected MUN. Including marginal variables would increase the chance of spurious results.

5.4.2 Ration balancing

The CPM© energy estimates are known to be substantially influenced by NDF, lignin and NDF digestibility values (11). Accurate lignin values are recommended to correctly assess NDF digestibility (11). Attempts to estimate forage lignin were unsuccessful, so default CPM© library lignin values were utilized as a substitute for the true lignin values. As a result of using default CPM© library lignin values, the accuracy of CPM© energy estimates may not have been as reliable as our protein estimates, for which we had all the required input values.

The same ration ingredients were entered into two different ration analyzers. In most instances, CPM© predicted, on TMR and CR herds, that the rations were deficient in energy and protein. However, Spartan© predicted that the rations were excessive in protein and marginally deficient in energy. The exception to this was in the early lactation cow groups, which were able to meet their requirements through intake and body reserves.

In total, there were 790 individual rations entered into CPM©. The CPM© energy and protein fraction summary pertaining to the 790 rations demonstrated relatively narrow inter-quantile range, suggesting a level of similarity among the composition of the rations fed. There were many common ingredients that were fed between farms, such as barley and commercial dairy supplements. Despite this fact, it was remarkable how narrow the IQRs were, relative to the number of rations that were analyzed. From these narrow IQRs, one could gather that there is very little variation in the protein and energy fractions in Maritime dairy herd rations.

Spartan© and CPM© predicted similar energy profiles for mid- and late lactation TMR herds, but were opposite in terms of energy balance in all other instances. The lack of appropriate inputs to generate the CPM© energy estimates (due to the inability to correctly measure lignin) may have explained, in part, the observed differences in predicted CPM© and Spartan© energy profiles. What remains unexplained is the reason behind the notable difference between CPM© and Spartan© dietary protein profiles, even though all of the protein inputs were available.

5.4.3 MUN values during the non grazing period

During the non-grazing periods between October 1999 and January 2001, MUN values on TMR and CR herds, followed the same seasonal pattern. Work in Pennsylvania by Ferguson *et al.* (12) also found that mean MUN levels increased between winter and spring from 14.01 to 14.98 mg dl^{-1}, respectively. In the present study, it is difficult to identify the reason behind the observed increases in MUN levels in both TMR and CR herds during the spring confinement period because rations fed were similar to those fed earlier in the winter.

The MUN values were regressed on the CPM© ration data in order to determine which ration variables or group of variables could best account for the observed variations in MUN levels. The CPM© PER only accounted for an additional 0.5 % of the total observed variation in MUN. The Spartan© PER explained 5.9 %. This suggests that using typically available data, the latter may be a better estimate of the energy and protein balance in the ration.

When CPM© derived variables were regressed individually or as a group, they could only explain an additional 5.5 % of the observed MUN variation. These variables were no better than the Spartan© PER and were viewed as having limited explanatory value with regards to the observed variations in MUN.

The Spartan© PER accounted for 5.9 % of the variation that was observed in the MUN values. The stage of lactation, feed delivery and interaction terms only increased the amount of MUN variation that could be explained by .79 % after the PER had been accounted for. The biological rationale of the PER was reinforced by the statistical significance of the PER coefficient, and when compared to all other variables, the PER explained the greatest amount of the observed variation in MUN in Spartan©.

The very small proportion of the variability in MUN explained by the nutritional factors in this study stands in marked contrast to results obtained under tightly controlled experimental conditions. Roseler *et al.* (1) evaluated the relationship between degradable intake protein (DIP), undegradable intake protein (UIP), net energy of lactation (NE_l) and plasma urea nitrogen in fifteen Holstein cows. Five early, mid- and late lactation cows were fed, once daily over a three week period, one of five diets which varied in degradable and undegradable protein. Cows were fed once daily at 1100 h, milked at 0100h and 1300 h and a milk sample was collected by hand at 1000 h. Cows were housed in individual stalls. The third week of the trial was used as the sampling period. Milk samples were collected on day 17, 19 and 21 of the trial. Their general linear model, which included DIP, UIP and NE_l as predictors of PUN, explained 67% of the variation in PUN. They also found that the milk non-protein nitrogen (MNPN) component was best explained by the PUN concentration and yield of milk per day (R^2 = 0.86).

Schepers and Meijer (5) evaluated dietary nitrogen utilization based on MUN concentrations. Milk samples were collected every week from four consecutive milkings The fixed part of their model explained 69 % of the variation in the natural logarithm of the MUN concentration. Their model accounted for a much larger proportion of the variation than the MUN study model (69 % vs 5 %).

Broderick *et al.* (4) also conducted a statistical evaluation of animal and nutritional factors that influenced MUN concentrations. Milk urea nitrogen predictors included BUN, CP/NE_l , CP, NE_l. Their mixed effects model had an R^2 equal to 0.875. The inclusion of BUN in the model could have contributed to this elevated R^2. Blood urea nitrogen and

MUN are highly correlated, by including another measure of urea status (BUN) as a predictor of MUN an inflated R^2 could be expected. This model may also have an underlying collinearity problem as both components of the CP/NE_l ratio are included as individual predictors of MUN. The model of Oltner *et al.*(3), which contained the CP /metabolizable energy (ME) ratio and the digestable CP/ ME ratio, had an adjusted R^2 equal to 33 %.

The above models would indicate that in an experimental setting, when diet composition and sampling times between feeding and milking are tightly controlled, there exists a strong relationship between ration composition and MUN. The strength of the relationship drastically decreases when it is assessed in the field under commercial settings where diet composition and sampling times are quite variable. However, nutritional consultants must base decisions using inputs similar or inferior to those in the current field-based project.

The reason for the dramatically lower ability of ration composition data to predict MUN values under commercial conditions compared to tightly controlled experimental conditions are not known. However, it may represent a combination of more variability of the test-day MUN levels than are observed in experimental conditions and a reduced ability to determine the energy and protein composition of the diet. Individual cow test-day MUN values may be more variable due to greater variation in factors such as time from feeding to milk sample collection in commercial herds than under experimental conditions. The quality of the ration composition data is lower in field conditions because it is based on determining the feed composition but estimating the quantity of each feed that is consumed. Under experimental conditions, the exact composition and quantities are usually known. However, the evaluation of the rations fed in this study was much more rigorous than would characteristically be done under commercial conditions, at least for small herds in this region. Consequently, routine ration evaluation information may have a limited ability to predict MUN values. Conversely, MUN values may not consistently and reliably reflect the energy and protein balance in the ration.

There were a number of significant interaction terms present in the Spartan© MLM. There was significant interaction between the PER, feed delivery and stage of lactation. Interpretation of the model coefficients indicated that mid- lactation animals were predicted to have the highest MUN levels when early lactation animals were utilized as a baseline comparison. The stage of lactation effect was not as pronounced when the PER was 1.1 compared to the PER was 0.97 (Table 5.8). Based on the model predictions, one could presume that herds, which are ingesting an energy deficient and/or protein excessive diet, have MUN levels that are less influenced by the stage of lactation effect.

Increases in the PER from .97 to 1.1 (Table 5.8) always resulted in an increase in the predicted MUN value throughout lactation regardless of the feed delivery system, although this effect was less in the TMR herds. This observation coincides with what would be expected with a decrease in energy and/or an increase in protein. However, the effect was small. This suggests that changes in the protein-energy balance in the diet, at the herd level, may only have a limited impact on individual cow-test day MUN values as they are currently measured under normal, routine field conditions.

In this study, the mean MUN values on TMR herds were lower when compared to CR herds during the spring and fall 2000 visits and higher during the fall 1999 visit. Research pertaining to feeding strategy and MUN values is limited. Carroll *et al.*(13) investigated the influence of protein intake and feeding strategy on the reproductive performance of dairy cows. Their research demonstrated results similar to those found in the current MUN study. Cows which consumed diets with the similar percent CP, but fed under two different feeding strategies (TMR vs CR), had PUN levels equal to 16.8 ± 0.3 and $17.6 \pm .3$ mg dl^{-1} in the TMR and component ration groups, respectively. Because the objective of their research was reproductive performance as opposed to rumen physiology, it offered no explanation for the observed difference in PUN levels between the two feeding strategies.

The observed difference in predicted MUN levels on TMR and CR herds could, in part, be explained by the ration formulation associated with the TMR system. A one group TMR system ration is balanced for a predetermined level of milk production. This predetermined level is generally below the peak milk production requirement but is above the late lactation requirements. The peak lactation deficiencies may be addressed with computer feeders or top-dressing in the parlor. The late lactation animal excess cannot be corrected. Perhaps this energy excess is, in part, contributing to the decreases in observed MUN levels.

There is more flexibility regarding to protein and energy delivery in CR herds. In this group of farms, the producers can control the amount of energy and protein that late lactation animals are receiving and prevent excesses in energy intake. This difference in ration formulation may explain, in part, why MUN levels from late lactation animals in TMR herds are predicted to be 0.4 mg dl^{-1} lower than late lactation cows from CR herds. The biological relevance of this MUN difference between TMR and CR herds is questionable because the difference was small and fell within the normal MUN range.

5.5 Conclusion

There was an unexplained rise in MUN that took place during the Spring 2000 confinement period. Based on the narrow IQR in CPM© protein and energy fraction estimates, there appeared to be very little variation in the protein and energy fractions in feed on Maritime dairy herds. The low level in variation may have contributed to its lack of ability to predict MUN values. Detailed breakdown of the energy and protein fractions in the diet added very little to the ability of the ration information to predict MUN when compared to a simple measurement of the total energy and protein that was fed. The Spartan© PER explained 5.9 % of the observed variation in MUN. Under commercial settings, the relationship between MUN and dietary components was weaker than has been reported from studies carried out under controlled experimental settings, suggesting that MUN from ADLIC testing may be of limited value as a nutritional monitoring tool than would have been expected from the experimental study results. The effect of PER on MUN values depended on stage of lactation and feed delivery system. Lack of flexibility in energy and protein delivery in TMR herds could explain, in part, the observed differences between TMR and CR groups.

5.6 References

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Chapter 6

Conclusion

6.1 Introduction

The overall objective of the MUN project was to develop guidelines for the use of MUN values in Atlantic Canadian dairy herds. In order to produce guidelines that could be utilized in the field, it was essential that the researchers had: 1) a thorough understanding of nutritional and non-nutritional factors that affect MUN levels, 2) knowledge of the effects of MUN on reproductive performance if MUN interpretations were to expand beyond nutritional monitoring, and 3) Results from an intervention trial to test the application of the new guidelines and thereby validate the study findings. This thesis is focused on objective 1.

Establishing the efficiency of MUN levels as a herd nutritional monitoring tool under commercial conditions would be very beneficial to dairy producers, nutritionists, and veterinarians. Feed trials have demonstrated positive associations between MUN and dietary protein, UIP, DIP and a negative association between MUN and energy intake. The importance of the protein:energy ratio of a ration and how the overall CP levels can mask UIP and DIP imbalances have also been demonstrated (1-4). All of the previous studies were based on a relatively small number of cows or small feed trials kept under tightly controlled experimental conditions. Results from a large scale observational study involving PEI dairy herds would clarify how nutritional and other factors affect MUN in cows maintained under commercial conditions on PEI The desire to pursue this objective was the founding idea behind this component of the MUN study.

Four major objectives were addressed in this component of the MUN study. The first of these objectives was to describe the nutritional management of the 93 study herds which operated under different commercial management conditions. This included describing: what was being fed, how it was being fed and the feedstuff composition during the grazing and non-grazing periods. The second objective was the development of a rising plate meter predictive model applicable to PEI permanent pastures during the summer 2000 grazing period. The completion of these two objectives allowed the researcher to achieve the last two objectives, which were:

1) To identify the significant factors associated with seasonal variation in milk urea nitrogen, observed during the summer in dairy herds on intensively and extensively managed pastures.
2) To assess the impact of dietary protein and energy levels, energy and protein fractions, method of ration delivery, feeding frequencies and ionophore utilization on MUN levels during the non-pasture period.

6.2 Herd demographics and nutritional management

Eighty three dairy herds from PEI and 9 dairy herds from NS were included in the study. In the winter, PEI herds were classed as 22 TMR and 61 CR, respectively. Nova Scotia herds were all classified as TMR in the winter. Prince Edward Island summer classification was 22, 28, 29 and 4 for total confinement TMR, extensive grazing manager, intensive grazing manager and grazing TMR herds, respectively. All NS herds were total confinement TMR herds.

The first goal was to quantify and qualify what was being fed in the 93 study herds and describe how it was being delivered during the summer and winter periods. Feed stuff composition was relatively uniform within each of the harvest seasons, between harvest seasons, between provinces and among herd classifications.

Herd demographics and management practices were not as uniform. Herd size, milk production, grain feeding delivery in CR herds, grain processing techniques, ionophore utilization and silage storage differed substantially between herds.

6.3 Development of a rising plate meter predictive model

The magnitude of the MUN study necessitated a quick and easy way to determine forage availability on pastures. This necessitated the second objective of this component of the MUN study which was the development of a rising plate meter (RPM) predictive model applicable to PEI permanent pastures during the summer 2000 grazing period.

Basic statistical principles were applied to ensure the creation of accurate predictive models. The evaluation of the predictive ability of the RPM showed that different predictive models were required for the spring and summer periods. The estimate of the Spring and Summer RPM calibration models were as follows:

Spring kg DM ha^{-1} = - 1184 + 211 RPMR

Summer kg DM ha^{-1} = 535 + 110 RPMR.

Each model had reasonably good predictive ability (spring $R^2 = 0.59$, summer $R^2 = 0.68$) and concordance with observed pasture production values (spring concordance correlation = 0.75, summer concordance correlation = 0.81) and was reasonably robust. Models were considered valid when the RPM readings were taken from permanent PEI pastures and the sampling period definitions were respected.

6.4 Identification of significant factors associated with seasonal variation in milk urea nitrogen in cows grazing intensively and extensively managed pasture

Pasture is an important source of forage for PEI dairy farms. Prince Edward Island milk urea nitrogen values peaked during the 1999 and 2000 grazing periods. These results prompted an intensive study which identified significant factors associated with seasonal variation in milk urea nitrogen in cows grazing intensively and extensively managed pasture.

Included among the variables evaluated were: pasture management practices and pasture supplementation. These variables are known to have an effect on dietary CP and carbohydrate levels (5-8). Seasonal increases in MUN could have resulted from changes in both dietary protein and/or energy.

Multi-level model analysis identified stage of lactation, grazing management, milk yield, the presence of ryegrass and the protein-energy ratio (PER) as significant predictors of MUN. Inclusion of ryegrass in the multilevel model produced a significant interaction term between ryegrass and intensive grazing management. The model which included ryegrass predicted MUN levels to be 3.9 mg dl^{-1} higher in IGM herds that utilized ryegrass when compared to EGM herds that did not utilize ryegrass. Very little of the MUN herd level variation could be explained by the nutritional parameters measured. Approximately half of the cow level observed variation in MUN could be explained and a small proportion of the test day variation was explained. Increased MUN levels during mid-lactation can partially be explained by the relatively low energy levels fed to cows in the study herds at this stage of lactation when compared to early lactation animals.

Attention must be paid to carbohydrate levels in rations that contain ryegrass. Carbohydrates in ryegrass are not readily available (9;10) . This is especially important in mid- lactation rations which tend to be relatively lower in energy. A better understanding of ryegrass structure and ruminal degradation would be helpful and would allow us to make sound nutritional recommendations that could result in improved efficiency of nitrogen utilization.

6.5 Impact of dietary protein and energy levels, energy and protein fractions, method of ration delivery, feeding frequencies and ionophore utilization on MUN levels in cows not on pasture.

Little work has been done which quantifies energy and protein delivery relative to protein and energy requirements in relation to MUN levels, particularly under commercial conditions. The significance of protein and energy fractions, feeding frequency, ration delivery and feed additives with respect to MUN levels has not been investigated in a large study of commercial herds. As a result, the impact of dietary protein and energy levels, energy and protein fractions, method of ration delivery, feeding frequencies and ionophore utilization on MUN levels were investigated.

Variance estimates, after adjustment for stage of lactation and feed delivery, indicated that the CPM© protein-energy ratio (PER) could only explain 0.5 % of the total variation in MUN .When all the protein and energy fractions (9 independent variables) were included in a multilevel model, only 5.5 % of the residual variation in MUN could be explained. In general, the nutritional parameters were only able to explain a very small amount of the total variability in MUN. However they did explain approximately 15 % of each of the herd and cow level variances. The Spartan© PER explained 5.9 % of the residual variation in MUN. The addition of ionophor utilization and feeding frequency could only explain an additional 0.8 % of the residual variation. The inclusion of PER, TMR, stage of lactation and significant two way interactions only explained 6.7 % of the total variation or 12.7 % of the herd variation.

Detailed breakdown of the protein and energy fractions added very little to the ability to predict MUN when compared to a simple measurement of the total energy or protein fed in the diet. Under non-experimental commercial conditions, the relationship between MUN and dietary components is much less consistent than under a controlled environment.

6.6 Summary

The RPM was a useful tool to estimate forage biomass availability when the RPM readings were taken from permanent PEI pastures and the sampling period definitions were respected.

Ration formulation during the grazing period must take carbohydrate availability into consideration, especially when ryegrass is being ingested. Increased carbohydrate supplementation during the grazing period could improve efficiency of nitrogen utilization and prevent MUN increases during the grazing period.

During the confinement period detailed CPM© breakdown of the energy and protein fractions added very little in our ability to explain the observed variation in MUN when compared to a simple measurement of the total energy and protein that was ingested.

Under non-experimental, commercial conditions, the relationship between MUN and dietary components is much weaker than under a controlled environment. The PER explained only 5.9 % of the observed variation in MUN.

In our study, utilizing ration analysis, animal intake and feed delivery data that would be available to nutritional advisors and MUN data from commercial DHI sources, MUN was of limited value to predict nutritional management. Further analysis in herds with differing feeding regimes and more variable MUN values is warranted.

6.7 References

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Appendix A
Initial Atlantic Dairy Livestock Improvement Corporation survey

Milk Urea Nitrogen Project
Feeding Survey

PEI Dairy producers Assoc.

Faculty at the Atlantic Veterinary College in cooperation with ADLIC and the PEI Dairy Producers' Association are currently conducting research into Milk Urea Nitrogen (MUN) technology in PEI. The research is supported financially by the Agricultural Research Investment Fund of the PEI Department of Agriculture, the
Industrial Research Assistance Program of the National Research Council and the Adaption and Development of Agricultural Production Technology (ADAPT) Council. The first phase of the project, monthly analysis of all cows on the ADLIC program began in April, 1999. One objective of the project is to examine the effect of different feeding programs on MUN values. To reach this objective we must identify herds using a variety of feeding approaches. Based on answers given in the attached survey, approxiamtely 80 PEI herds will be randomly chosen to take part in the second phase of the project. **Herds that are chosen to participate in this second phase will receive a number of feed analysis over a 2 year period free of charge.** All information collected in this survey will be keep strictly confidential.

11) Producer Name_ Producer ADLIC #_

2) Herd size (total of dry and milking cows) :_

3) Breed: (Check (✓) ALL that apply)
Holstein ❑ Ayrshire ❑ Guernsey ❑ Jersey ❑ Other_

FEEDING DURING THE STABLED PERIOD (WINTER)

4) In winter, does the concentrate portion of your ration contain:

i) a commercial dairy ration ❑
Describe briefly:

eg. 18% Co-op pellet with a 38% top dress to top producers

ii) Raw components ❑
Describe briefly:

eg. 40% barley, 30% mixed grain 20% soybean meal 10% extruded soybean with roasted soybeans as top dress to top producers

iii) Combination of prepared and raw ingredients ❑
Describe briefly:

eg. 40% barley, 30% mixed grain 30% commercial supplement

5) What forages are feed in the winter to the milking cows?✓all that apply

Dry Hay❑ Round Bale Silage ❑

Chopped hay silage ❑ from a -

Tower silo ❑ Bunker silo ❑ AgBag ❑ Other ___________

iv) Corn Silage from a -

Tower silo ❑ Bunker silo ❑ AgBag ❑ Other ___________

xii) Other forages (Please Specify)

6) This winter, did you feed a total mixed ration (TMR) in which the forage and concentrate portions were mixed together prior to feeding?

YES ❑ NO ❑

If YES, a) Briefly describe it's ingredients:

b) Did you supplement any groups (computer feeder - topdress in tiestall)?

YES ❑ NO ❑

Describe this supplementation: ie how many times per day? By what method?

If you do not feed a TMR,

a) How many times per day was grain/protein fed? _

FEEDING DURING THE SUMMER MONTHS

7) Did you feed a total mixed ration (TMR) last summer? Yes ❑ No ❑

If YES, a) Briefly describe (if different than winter):

b) Did you supplement any groups? Yes ❑ No ❑

c) Describe this supplementation: If different than winter.

If NO, a) How many times per day was grain/protein fed in summer?_

8) Was pasture used to provide forage for milking cows last summer?

Yes ❑ No ❑

If YES, What statement best describes your pasture usage: (✓ ONE only)

Remain in the same pasture all summer ❑

Change fields during the summer ❑

New sections available while continued access to earlier areas ❑

Strip grazing or paddocks ❑

Describe the level of pasture availability:

Total number of acres used for pasturing the milking herd in 1998__.

Maximum number of acres available to pastured milk cows at 1 time in 1998_

Appendix B
Grazing management index (GMI) calculations

Relative score (RS) formula:

$$RS = [(\text{subject herd variable score}) - (\text{minimum variable score among all herds})] * \frac{\text{maximum possible RS value}}{\text{variable range among all herds}}$$

Table B-1: Maximum relative score (RS) value for the individual grazing management and grazing land management variables.

Grazing Management Variables	Maximum RS	Grazing land management variables	Maximum RS
Stocking density (Largest paddock)	25	Re-seeding frequency	6.25
Acreage utilization	25	NPK fertilizer	N/A
Grazing period	25	Ammonium nitrate	N/A
		Manure application	N/A

Table B-2: Variable score ranges for all herds included in the grazing management index calculation for the individual grazing management and grazing land management variables.

Grazing Management Variables	Variable score range	Grazing land management variables	Variable score range
Stocking density (Largest paddock)	2-12	Re-seeding frequency	1-10
Acreage utilization	1-11	NPK fertilizer	N/A
Grazing period	1 - 14	Ammonium nitrate	N/A
		Manure application	N/A

Table B-3: Subject farm "A" variable scores for the individual grazing management and grazing land management variables.

Grazing Management Variables	Variable score	Grazing land management variables	Variable score
Stocking density (Largest paddock)	8	Re-seeding frequency	6
Acreage utilization	8	NPK fertilizer	yes
Grazing period	2	Ammonium nitrate	yes
		Manure application	no

Table B-4: Subject "A" example GMI calculation

Variable	Relative score calculation	Relative score
Stocking density	(8 - 2) * 25 /10	15
Acreage utilization	(8 - 1) * 25 / 10	17.5
Grazing period	25 - [(2 - 1) * 25 / 13]	23.1
Re-seeding frequency	6.25 -[(6 - 1) * 6.25 / 9]	2.8
NPK fertilizer	present	6.25
Ammonium nitrate	present	6.25
Manure application	absent	0
Total (GMI score)	sum of individual scores	70.9

APPENDIX C:
SURVEYS
Appendix C-1
INITIAL FARM VISIT NUTRITIONAL MANAGEMENT SURVEY

Date:__________ ADLIC ID:____________
Milk pick up number: ___________________
Producer name:______________________________
Housing

1 free stall 2 tie stall (stanchion) 3 tie stall (neck chain)

cows milked today:__________ # dry cows:__________________

FEEDING MANAGEMENT

System utilized: (1) TMR (2) Component

Concentrate feeding: (1) Manual (2) Computer

(3) Automated (4) N/A

Concentrate:

Frequency of feeding (day^{-1}) : 1 2 3 4 5 6

Forage:

Frequency of feeding (day^{-1}) : 1 2 3 4 5 6

Orts

(1) none (2) fed back to milking herd (3) discarded

MUN PROJECT

ON FARM VISIT CHECK LIST

_____Forage samples _____Water samples _____Release forms

_____ Particle size forage sample

Copy of forage analysis sent out to:

SPECIFIC NUTRITIONAL INFORMATION

TMR HERDS ONLY

group name ____________ ____________ ____________

cows \ group ____________ ____________ ____________

feedings per day ____________ ____________ ____________

Balanced for

Kg or lbs milk ____________ ____________ ____________

Feed ingredients -------------------------as fed amount---------------------------

____________ ____________ ____________ ____________
____________ ____________ ____________ ____________
____________ ____________ ____________ ____________
____________ ____________ ____________ ____________

TOTAL MIX ____________ ____________ ____________
Milk Production ____________ ____________ ____________

FORAGE INVENTORY

FORAGE HARVEST DATES SAMPLED (Y / N)

SPECIFIC NUTRITIONAL INFORMATION
(COMPONENT HERDS ONLY)

FEED STUFF	fed (Y/N)	sampled	Gr 1	Gr2	Gr3	COMMENTS
			--- Amount eaten (Kg or Lbs) --			*Approx wt. round bales, size *Harvest dates *Forage storage
____	____	____	____	____	____	____
____	____	____	____	____	____	____
____	____	____	____	____	____	____
____	____	____	____	____	____	____

	GROUP 1 (40 - 60 DIM)	GROUP 2 (120 - 150 DIM)	GROUP 3 (> 200 DIM)
DEFINITION OF GROUP	________ kg	________kg	________kg
NUMBER OF COWS TODAY	________	________	________

Appendix C-2

PHONE NUTRITIONAL MANAGEMENT SURVEY, MARCH 2000

Date:_________ ADLIC ID:___________

Milk pick up number: _________________

Producer name:___________________________

IONOPHORES

Do you use Rumensin in the lactating animals ? Y / N

If yes:

1) Is it a constant amount that is added to a certain feedstuff ? Y \ N

Dosage:_________ Feedstuff:__________

2) CRC Bolus ? Y \ N

3) Other methods & dosage: _____________________

GRAINS

How is your grain processed?

Fall 99 ____whole ____ rolled ____cracked ____crushed ____ other

March 00 ____whole ____ rolled ____ cracked ____ crushed ____ other

PASTURE FERTILISATION 99

Manure applied: Y \ N

frequency _____ ____l ___m ___h

Chemical fertilizer

Type: ____N _____P ____K

rate _____ frequency_____

Nitrogen application

Type : ______ N

Frequency ______ rate______

SPECIFIC QUESTIONS PERTAINING TO FALL SURVEY:

SPECIFIC NUTRITIONAL INFORMATION
(COMPONENT HERDS ONLY)

	50 DIM	120 DIM	200 DIM
MILK PRODUCTION			
GRAIN FEEDING FREQ			
FORAGE FEEDING FREQ			

--- Amount eaten (Kg or Lbs) --

feed stuff	sampled (Y/N)	40-60 DIM	120 DIM	200 DIM	COMMENTS

SPECIFIC NUTRITIONAL INFORMATION
(TMR HERDS ONLY)

	GROUP 1 computer feeder y/n	GROUP2 computer feeder y/n	GROUP 3 computer feeder y/n
# COWS			
MILK PRODUCTION			
DURATION OF BATCH			
# TIMES FED PER DAY			

— amount / batch or cow (Kg or Lbs) --

feed stuff	sampled (Y/N)	GROUP 1	GROUP 2	COMMENTS

Appendix C-3

PASTURE SURVEY, SUMMER 2000

Date:_________ ADLIC ID:___________

Producer name:____________________________

IONOPHORES

Do you use Rumensin in the lactating animals ? Y / N

If yes:

1) Is it a constant amount that is added to a certain feedstuff ? Y \ N

Dosage:________ Feedstuff:__________

Bolus Y / N

GRAINS

How is your grain processed?

Summer 00 ____whole ____ rolled ____ cracked ____ crushed ____ other

PASTURE FERTILISATION 2000

Manure applied: Y \ N

frequency _____ ____l ___m ___h

Chemical fertilizer

Type: ____N _____P ____K

rate _____ frequency_____

Nitrogen application

Type : ______ N

Frequency ______ rate______

Milking Times

a.m. _______

p.m. _______

SPECIFIC NUTRITIONAL INFORMATION
(COMPONENT HERDS ONLY)

	50 DIM	120 DIM	200 DIM
MILK PRODUCTION			
GRAIN FEEDING FREQ			
FORAGE FEEDING FREQ			

--- Amount eaten (Kg or Lbs) --

feed stuff	sampled (Y/N)	40-60 DIM	120 DIM	200 DIM	COMMENTS

Appendix C-4

PHONE NUTRITIONAL MANAGEMENT SURVEY, SUMMER 2000

Date:_________ ADLIC ID:___________ ADLIC test date___________

Producer name:____________________________

IONOPHORES

Do you use Rumensin in the lactating animals ? Y / N

If yes:

1) Is it a constant amount that is added to a certain feedstuff ? Y \ N

Dosage:_________ Feedstuff:__________

2) CRC Bolus ? Y \ N

3) Other methods & dosage: ______________________

GRAINS

How is your grain processed?

Summer 2000 ____whole ____ rolled ____cracked ____crushed ____ other

Are your cows utilizing pasture ? Y / N If no skip pasture fertilisation section

PASTURE FERTILISATION Spring 2000

Manure applied: Y \ N

frequency _____ ____l ___m ___h

Chemical fertilizer

Type: ____N _____P ____K

rate _____ frequency_____

Nitrogen application

Type : ______ N

Frequency ______ rate______

Do you have any silage that need to be sampled and submitted to the lab? Y / N
If yes when is a good time for us to go out and collect it?___________________________

SPECIFIC NUTRITIONAL INFORMATION
(COMPONENT HERDS ONLY)

	50 DIM	120 DIM	200 DIM
MILK PRODUCTION			
GRAIN FEEDING FREQ			
FORAGE FEEDING FREQ			

--- Amount eaten (Kg or Lbs) --

feed stuff	sampled (Y/N)	40-60 DIM	120 DIM	200 DIM	COMMENTS

SPECIFIC NUTRITIONAL INFORMATION
(TMR HERDS ONLY)

	GROUP 1 computer feeder y/n	GROUP2 computer feeder y/n	GROUP 3 computer feeder y/n
# COWS			
MILK PRODUCTION			
DURATION OF BATCH			
# TIMES FED PER DAY			

— amount / batch or cow (Kg or Lbs) --

feed stuff	sampled (Y/N)	GROUP 1	GROUP 2	COMMENTS

Appendix C-5

MUN PROJECT FINAL FARM VISIT NUTRITIONAL MANAGEMENT SURVEY

Date:__________ ADLIC ID:____________ Phone #_____________ Fax #____________

Producer name:______________________________

Housing

(1)free stall (2) tie stall (stanchion) 3 tie stall (neck chain) (4) manure pack

cows milked today:__________ # dry cows:__________________

FEEDING MANAGEMENT

System utilized: (1) TMR (2) TMR & computer feeder (3) Component (4) ITMR

Concentrate feeding: (1) Manual (2) Computer (3) Automated (4) other: _________________________

TMR feeding:

_______ X

Concentrate:

Frequency of feeding (/day) : 12 3 4 5 6

__whole ___ cracked ___rolled ___ crushed

Forage:

Forage storage (1) RBS (2) URS (3) Bunk silo (4) Heep silo (5) Agr. Bag

Frequency of feeding (/day) : 12 3 4 5 6

Corn Silage:

Corn silage storage (1) RBS (2) URS (3) Bunk silo (4) Heep silo (5) Agr. Bag

Frequency of feeding (/day) : 12 3 4 5 6

Rumensin Y / N

PASTURE MANAGEMENT

Zero grazing: Y / N

Total Acres of pasture:____________ Total # of paddocks:______________

Ryegrass : Y / N if yes date on pasture: ________

field id	size (acres)	distance to mid-field[A]	lime in past 5 years	re seeded[B]	Clipping[C]	ryegrass	strip grazin g	after grass	water in field
1		1, 2, 3	Y / N	1, 2, 3	1, 2, 3	Y / N	1, 2, 3	Y / N	Y / N
2		1, 2, 3	Y / N	1, 2, 3	1, 2, 3	Y / N	1, 2, 3	Y / N	Y / N
3		1, 2, 3	Y / N	1, 2, 3	1, 2, 3	Y / N	1, 2, 3	Y / N	Y / N
4		1, 2, 3	Y / N	1, 2, 3	1, 2, 3	Y / N	1, 2, 3	Y / N	Y / N
5		1, 2, 3	Y / N	1, 2, 3	1, 2, 3	Y / N	1, 2, 3	Y / N	Y / N
6		1, 2, 3	Y / N	1, 2, 3	1, 2, 3	Y / N	1, 2, 3	Y / N	Y / N
7		1, 2, 3	Y / N	1, 2, 3	1, 2, 3	Y / N	1, 2, 3	Y / N	Y / N
8		1, 2, 3	Y / N	1, 2, 3	1, 2, 3	Y / N	1, 2, 3	Y / N	Y / N
9		1, 2, 3	Y / N	1, 2, 3	1, 2, 3	Y / N	1, 2, 3	Y / N	Y / N

A: Distance from mid field: (1) < 300 m (2) 300- 500 m (3) > 500m

B: Re seeding of pastures: (1) 1-2 years ago (2) 5-10 years ago (3) > 10 years ago

C: Clipping: (1) none (2) once per season (3) more than once per season

D: Strip grazing (1) true strip grazing (2) forward strip grazing (no follow up fence) (3) none

JUNE	JULY	AUGUST	SEPT.
# fields ID #:	# fields ID #:	# fields ID #:	# fields ID #:
Pasture management [A] 1 2 3	Pasture management [A] 1 2 3	Pasture management [A] 1 2 3	Pasture management [A] 1 2 3
How often are the cows moved[B]: 1 2 3 4 5 6 7	How often are the cows moved[B]: 1 2 3 4 5 6 7	How often are the cows moved[B]: 1 2 3 4 5 6 7	How often are the cows moved[B]: 1 2 3 4 5 6 7
On average how long before cow are back on same field:_______	On average how long before cow are back on same field:_______	On average how long before cow are back on same field:_______	On average how long before cow are back on same field:_______

A) 1 = continuous 2 = strip 3 = rotational

B) How often are cows moved from paddock: (1) AM PM (2) every day (3) every other day
(4) once / week (5) every other week
(6) same pasture all summer (7) other

FERTILIZATION RECORD

PERIOD	NPK RATE	MANURE: L M H
SPRING 99		
FALL 99		
SPRING 00		
SUMMER00		

BCS

DIM	DIM	DIM	DIM	DIM	DIM
BCS	BCS	BCS	BCS	BCS	BCS

SPECIFIC NUTRITIONAL INFORMATION
(COMPONENT HERDS ONLY)

	50 DIM	120 DIM	200 DIM
WEIGHT			
MILK PRODUCTION			
GRAIN FEEDING FREQ			
FORAGE FEEDING FREQ			

HERD AVERAGE MILK PRODUCTION:

--- Amount eaten (Kg or Lbs) --

feed stuff	sampled (Y/N)	40-60 DIM	120 DIM	200 DIM	COMMENTS

SPECIFIC NUTRITIONAL INFORMATION
(TMR HERDS ONLY)

Transition from high group to low group occurs at _______DIM

	GROUP 1 computer feeder y/n	GROUP2 computer feeder y/n	GROUP 3 computer feeder y/n
# COWS			
MILK PRODUCTION			
DURATION OF BATCH			
# TIMES FED PER DAY			

— amount / batch or cow (Kg or Lbs) --

feed stuff	sampled (Y/N)	GROUP 1	GROUP 2	COMMENTS

Pen State Forage Separator Data

	TOP	MIDDLE	BOTTOM	TOTAL
EMPTY				XXXXXXXX
SILAGE				XXXXXXXX
DIFFERENCE				
PERCENT				XXXXXXXX
EMPTY				XXXXXXXX
SILAGE				XXXXXXXX
DIFFERENCE				
PERCENT				XXXXXXXX
EMPTY				XXXXXXXX
SILAGE				XXXXXXXX
DIFFERENCE				
PERCENT				XXXXXXXX
EMPTY				XXXXXXXX
SILAGE				XXXXXXXX
DIFF				
PERCENT				XXXXXXXX
Corn Silage	2 - 4%	40 - 50%	40 - 50%	XXXXXXXX
Grass Silage	10 - 15%	30 - 40%	40 - 50%	XXXXXXXX
TMR	6 - 10%	30 - 50%	40 - 60%	XXXXXXXX

CHECK LIST

MANURE SAMPLE

WATER SAMPLE

Appendix D
Crude Protein

Appendix D contains descriptive statistics for crude protein on the various PEI feedstuffs fed during the study

Table D-1: Descriptive statistics pertaining to silage crude protein and individual sampling periods.

Forage	Visit	n	Median	Mean	Std. dev.	Min.	Max.
First cut grass silage	Fall 99	15	14.5	14.53	2.45	11.93	21.47
First cut grass silage	Spring 00	21	14.49	14.37	2.43	8.65	17.89
First cut grass silage	June 00	16	13.72	13.72	3.36	7.57	19.19
First cut grass silage	July 00	1	15.03	15.03	N\A	15.03	15.03
First cut grass silage	August 00	3	14.71	14.34	2.03	12.16	16.16
First cut grass silage	September 00	2	15.74	15.74	0.60	15.31	16.16
First cut grass silage	Fall 00	20	12.59	12.66	2.38	8.98	16.32
Second cut grass silage	Fall 99	3	14.49	14.31	0.46	13.79	14.66
Second cut grass silage	Spring 00	3	15.60	15.25	1.32	13.79	16.36
Second cut grass silage	June 00	2	15.38	15.38	1.58	14.26	16.49
Second cut grass silage	Fall 00	2	13.80	13.80	1.40	12.81	14.79
First cut mixed silage	Fall 99	50	14.70	14.95	2.44	10.35	19.97
First cut mixed silage	Spring 00	47	16.05	15.83	2.7	10.14	22.55
First cut mixed silage	June 00	27	14.92	15.48	2.01	12.29	19.48
First cut mixed silage	July 00	2	13.87	13.87	2.69	11.96	15.77
First cut mixed silage	August 00	5	15.99	16.00	2.53	11.96	18.29
First cut mixed silage	September 00	1	12.48	12.48	N\A	12.48	12.48
First cut mixed silage	Fall 00	45	14.91	14.99	2.00	10.49	21.12
Second cut mixed silage	Fall 99	15	15.81	16.30	2.01	12.03	18.93
Second cut mixed silage	Spring 00	7	15.56	15.79	2.54	12.03	19.79
Second cut mixed silage	June 00	3	15.81	15.64	1.32	14.24	16.87
Second cut mixed silage	Fall 00	3	14.28	14.11	1.25	12.78	15.26
Third cut mixed silage	Fall 99	2	21.92	21.92	1.60	20.79	23.05
Third cut mixed silage	Spring 00	1	22.15	22.15	N\A	22.15	22.15
Third cut mixed silage	June 00	1	18.93	18.93	N\A	18.93	18.93
First cut legume silage	Fall 99	13	19.19	18.64	2.42	15.01	23.06
First cut legume silage	Spring 00	13	16	16.64	2.24	13.34	19.51
First cut legume silage	June 00	9	17.74	17.47	2.77	12.46	22.09
First cut legume silage	July 00	2	15.66	15.66	1.72	14.44	16.87
First cut legume silage	Fall 00	15	16.92	16.48	2.54	12.94	20.51
Second cut legume silage	Fall 99	6	18.47	17.85	3.83	11.3	22.68
Second cut legume silage	Spring 00	3	17.84	17.48	1.42	15.91	18.69
Second cut legume silage	June 00	3	17.95	17.69	1.94	15.63	19.49
Second cut legume silage	Fall 00	2	18.87	18.87	1.14	18.06	19.67
Third cut legume silage	Fall 99	2	23.31	23.31	0.43	23	23.61
Third cut legume silage	Spring 00	1	23.00	23.00	N\A	23	23
Third cut legume silage	Fall 00	1	18.30	18.30	N\A	18.3	18.3
First cut grain silage	Spring 00	1	18.16	18.16	N\A	18.16	18.16
Oatlage	Fall 99	1	20.13	20.13	N\A	20.13	20.13
Ryegrass silage	Spring 00	1	22.14	22.14	N\A	22.14	22.14
Ryegrass silage	August 00	1	11.68	11.68	N\A	11.68	11.6

Table D-2: Descriptive statistics pertaining to hay crude protein and individual sampling periods.

Hay	Visit	n	Median	Mean	Std. dev.	Min.	Max.
First cut grass hay	Fall 99	10	10.55	10.60	1.21	8.83	12.64
First cut grass hay	Spring 00	9	11.16	11.19	1.78	8.06	14.19
First cut grass hay	June 00	8	11.52	10.46	2.14	7.06	12.64
First cut grass hay	July 00	2	9.30	9.30	0.76	8.76	9.83
First cut grass hay	Fall 00	3	9.88	9.39	2.13	7.06	11.23
Second cut grass hay	Fall 99	2	13.47	13.47	1.03	12.74	14.19
Second cut grass hay	June 00	1	14.19	14.19	N\A	14.19	14.19
Second cut grass hay	August 00	1	14.72	14.72	N\A	14.72	14.72
Second cut grass hay	Fall 00	2	14.80	14.80	2.28	13.18	16.41
First cut mixed hay	Fall 99	12	10.67	10.85	1.24	9.01	12.84
First cut mixed hay	Spring 00	8	11.43	12.49	3.30	9.01	17.91
First cut mixed hay	June 00	8	11.82	11.98	1.09	10.14	12.84
First cut mixed hay	July 00	2	11.66	11.66	2.03	10.22	13.09
First cut mixed hay	August 00	2	8.85	8.85	1.94	7.47	10.22
First cut mixed hay	Fall 00	6	11.91	12.14	3.00	9.16	16.39
First cut legume hay	Fall 00	1	11.7	11.70	N\A	11.7	11.7

Table D-3: Descriptive statistics pertaining to green chop and individual summer visits.

Green Chop	Visit	n	Median	Mean	Std. dev.	Min.	Max.
Green chop sorghum	June 00	1	15.31	15.31	N\A	15.31	15.31
Green chop corn	June 00	1	14.88	14.88	N\A	14.88	14.88
Green chop corn	July 00	1	8.44	8.44	N\A	8.44	8.44
Green chop ryegrass	July 00	1	21.41	21.41	N\A	21.41	21.41

Table D-4: Descriptive statistics pertaining to grain crude protein and individual sampling periods.

Grain	Visit	n	Median	Mean	Std. dev.	Min	Max.
Barley	Fall 00	12	15.30	14.94	1.40	12.17	17.18
Barley	Spring 00	12	15.30	14.99	1.47	12.17	17.18
Barley	June 00	8	12.02	12.58	1.92	10.58	15.87
Barley	July 00	1	12.61	12.61	N\A	12.61	12.61
Barley	August 00	1	12.11	12.11	N\A	12.11	12.11
Barley	Fall 00	12	13.06	13.24	1.48	10.24	15.5
Wheat	Fall 99	3	12.78	14.06	2.21	12.78	16.61
Wheat	Spring 00	1	16.61	16.61	N\A	16.61	16.61
Wheat	Fall 00	4	15.53	15.35	1.65	13.25	17.09
Oats	Fall 99	1	13.67	13.67	N\A	13.67	13.67
Oats	Spring 00	1	13.67	13.67	N\A	13.67	13.67
Soy beans	Fall 00	1	45.60	45.60	N\A	45.6	45.6
Roasted soy beans	Fall 99	3	38.16	38.09	1.41	36.65	39.46
Roasted soy beans	Spring 00	3	38.16	38.09	1.41	36.65	39.46
Roasted soy beans	June 00	1	37.69	37.69	N\A	37.69	37.69
Roasted soy beans	Fall 00	3	37.27	35.86	3.66	31.7	38.6

Table D-5: Descriptive statistics pertaining to corn silage crude protein and individual sampling periods.

Visit	n	Median	Mean	Std. dev.	Min.	Max.
Fall 99	20	10.06	12.61	11.16	8.73	59.74
Spring 00	18	9.05	9.29	1.40	7.13	13.90
June 00	14	8.55	8.96	0.97	7.79	10.95
Summer	1	8.36	8.36	N\A	8.36	8.36
Summer (v3)	1	8.36	8.36	N\A	8.36	8.36
Fall 00	21	8.89	9.44	1.68	7.91	15.53

Table D-6: Descriptive Statistics pertaining to pasture crude protein and individual visits.

Visit	n	Median	Mean	Std. dev.	Min	Max.
June 00	22	16.38	16.42	3.91	9.99	26.81
July 00	22	19.61	18.49	4.70	8.73	25.08
August 00	18	20.26	20.83	2.86	15.6	26.14
September 00	13	21.21	20.59	4.18	10.94	25.28

Appendix E
Soluble Protein

AppendixE contains descriptive statistics pertaining soluble protein levels in PEI feedstuffs fed during the study period.

Table E-1: Descriptive statistics pertaining to silage soluble protein and individual sampling periods.

Silage	Sampling period	n	Median	Mean	Std.dev	Min.	Max.
First cut grass silage	Fall 99	12	48.45	47.88	12.66	27.07	68.38
First cut grass silage	Spring 00	20	50.93	49.59	12.38	12.74	66.59
First cut grass silage	June 00	16	57.25	52.63	11.77	24.91	66.78
First cut grass silage	July 00	1	60.47	60.47	N\A	60.47	60.47
First cut grass silage	August 00	3	48.80	42.80	13.15	27.72	51.88
First cut grass silage	September 00	2	45.46	45.46	4.73	42.11	48.8
First cut grass silage	Fall 00	20	51.72	52.36	12.20	23.5	71.7
Second cut grass silage	Fall 99	2	49.97	49.97	3.11	47.77	52.17
Second cut grass silage	Spring 00	2	55.27	55.27	0.95	54.6	55.94
Second cut grass silage	June 00	2	49.34	49.34	0.49	48.99	49.69
Second cut grass silage	Fall 00	2	57.70	57.70	14.45	47.48	67.92
First cut mixed silage	Fall 99	49	43.72	43.34	10.18	22.45	67.01
First cut mixed silage	Spring 00	44	43.71	44.96	10.32	27.04	66.82
First cut mixed silage	June 00	25	46.04	45.51	11.63	26.54	63.53
First cut mixed silage	July 00	2	51.59	51.59	6.04	47.32	55.86
First cut mixed silage	August 00	5	47.32	49.26	13.57	30.05	66.88
First cut mixed silage	September 00	1	53.66	53.66	N\A	53.66	53.66
First cut mixed silage	Fall 00	44	53.44	50.97	9.84	27.57	69.15
Second cut mixed silage	Fall 99	14	37.49	37.57	10.19	20.75	55.19
Second cut mixed silage	Spring 00	7	32.39	32.35	8.65	24.43	46.75
Second cut mixed silage	June 00	3	40.91	42.56	6.49	37.05	49.71
Second cut mixed silage	Fall 00	3	48.38	45.41	9.73	34.54	53.31
Third cut mixed silage	Spring 00	1	32.65	32.65	N\A	32.65	32.65
Third cut mixed silage	June 00	1	55.19	55.19	N\A	55.19	55.19
First cut legume silage	Fall 99	11	36.96	39.03	10.30	25.36	55.85
First cut legume silage	Spring 00	13	37.79	39.73	14.90	17.85	67.28
First cut legume silage	June 00	9	44.71	43.77	15.42	22.03	66.45
First cut legume silage	July 00	2	39.13	39.13	3.37	36.74	41.51
First cut legume silage	Fall 00	15	43.97	42.55	9.26	21.08	55.85
Sec. cut legume silage	Fall 99	4	32.65	33.23	11.18	20.15	47.46
Sec. cut legume silage	Spring 00	3	40.54	41.65	5.35	36.94	47.46
Sec. cut legume silage	June 00	3	36.88	39.74	7.21	34.4	47.95
Sec. cut legume silage	Fall 00	2	32.58	32.58	1.30	31.66	33.5
Third cut legume silage	Fall 99	2	53.26	53.26	23.22	36.84	69.68
Third cut legume silage	Spring 00	1	36.84	36.84	N\A	36.84	36.84
Third cut legume silage	Fall 00	1	40.87	40.87	N\A	40.87	40.87
Ryegrass silage	Spring 00	1	47.92	47.92	N\A	47.92	47.92
Ryegrass silage	September 00	1	42.97	42.97	N\A	42.97	42.97

Table E-2: Descriptive statistics pertaining to hay soluble protein levels and individual sampling periods.

Hay	Sampling period	n	Median	Mean	Std.dev.	Min.	Max.
First cut grass hay	Spring 00	1	2.42	2.42	N\A	2.42	2.42
First cut grass hay	June 00	3	13.65	11.80	8.61	2.42	19.33
First cut grass hay	Fall 00	3	19.33	21.45	9.05	13.65	31.38
Second cut grass hay	Fall 99	1	46.97	46.97	N\A	46.97	46.97
Second cut grass hay	September 00	1	27.57	27.57	N\A	27.57	27.57
Second cut grass hay	Fall 00	2	25.77	25.77	7.80	20.25	31.28
First cut mixed hay	Fall 99	1	18.84	18.84	N\A	18.84	18.84
First cut mixed hay	June 00	4	34.38	49.39	33.85	28.81	100
First cut mixed hay	July 00	1	31.56	31.56	N\A	31.56	31.56
First cut mixed hay	August 00	1	39.24	39.24	N\A	39.24	39.24
First cut mixed hay	Fall 00	6	30.17	34.77	17.13	20.1	66.49
First cut legume hay	Fall 00	1	22.76	22.76	N\A	22.76	22.76

Table E-3: Descriptive statistics pertaining to green chop soluble protein and individual sampling periods.

Green chop	Sampling period	n	Median	Mean	Std. dev.	Min.	Max.
Green Chop Sorghum	August 00	1	31.01	31.01	N\A	31.01	31.01
Green Chop Corn	August 00	1	41.02	41.02	N\A	41.02	41.02
Green Chop Corn	September 00	1	19.94	19.94	N\A	19.94	19.94

Table E-4: Descriptive statistics pertaining to grain soluble protein and individual sampling periods.

Grain	Sampling period	n	Median	Mean	Std. dev.	Min.	Max.
Soy Beans	Fall 00	1	87.16	87.16	N\A	87.16	87.16
Roasted Soy Beans	Fall 99	1	32.31	32.31	N\A	32.31	32.31
Roasted Soy Beans	Spring 00	1	32.31	32.31	N\A	32.31	32.31
Roasted Soy Beans	Fall 00	3	18.34	17.42	4.20	12.84	21.09

Table E-5: Descriptive statistics pertaining to pasture soluble protein and individual visits.

Sampling period	n	Median	Mean	Std. dev.	Min.	Max.
June 00	22	31.29	31.30	4.75	23.01	40.98
July 00	22	32.66	32.06	4.23	25.58	41.03
August 00	18	35.65	33.43	6.29	21.30	43.29
September 00	13	33.20	33.48	4.45	24.80	40.29

Table E-6: Descriptive statistics pertaining to corn silage soluble protein and individual sampling periods.

Sampling period	n	Median	Mean	Std. dev.	Min.	Max.
Fall 99	15	44.88	43.35	8.92	24.72	58.57
Spring 00	18	50.21	49.19	8.23	33.78	63.50
June 00	14	50.21	52.16	9.49	37.86	66.57
July 00	1	45.22	45.22	N\A	45.22	45.22
August 00	1	45.22	45.22	N\A	45.22	45.22
Fall 00	21	44.39	47.23	9.42	33.56	65.16

Appendix F

Bound Protein

Appendix F contains descriptive statistics pertaining bound protein levels in PEI feedstuffs fed during the study period.

Table F-1: Descriptive statistics pertaining to silage bound protein and individual visit.

Silage	Visit	n	Median	Mean	Std.dev	Min	Max.
First cut grass silage	Fall 99	14	5.69	6.43	2.06	3.43	10.29
First cut grass silage	Spring 00	20	5.95	6.57	2.52	3.01	13.34
First cut grass silage	June 00	15	5.87	6.99	3.78	1.94	12.73
First cut grass silage	July 00	1	6.42	6.42	N\A	6.42	6.42
First cut grass silage	August 00	3	5.39	5.80	0.86	5.23	6.79
First cut grass silage	September 00	2	5.41	5.41	1.95	4.03	6.79
First cut grass silage	Fall 00	20	6.01	6.50	1.76	3.78	11.78
Second cut grass silage	Fall 99	3	8.59	10.11	2.80	8.40	13.34
Second cut grass silage	Spring 00	3	5.74	6.60	1.73	5.47	8.59
Second cut grass silage	June 00	2	10.94	10.94	1.04	10.2	11.67
Second cut grass silage	Fall 00	2	5.29	5.29	1.39	4.30	6.27
First cut mixed silage	Fall 99	53	7.58	8.52	3.39	3.91	18.96
First cut mixed silage	Spring 00	47	7.83	8.47	3.33	3.27	16.99
First cut mixed silage	June 00	26	8.48	9.43	4.78	3.27	20.49
First cut mixed silage	July 00	2	8.36	8.36	2.38	6.68	10.04
First cut mixed silage	August 00	5	6.68	6.48	2.86	3.53	10.04
First cut mixed silage	September 00	1	7.76	7.76	N\A	7.76	7.76
First cut mixed silage	Fall 00	45	7.42	8.07	5.26	3.03	30.76
Second cut mixed silage	Fall 99	15	9.10	10.19	3.23	5.52	18.12
Second cut mixed silage	Spring 00	7	10.35	11.09	3.32	7.09	15.96
Second cut mixed silage	June 00	3	8.95	8.41	2.67	5.52	10.77
Second cut mixed silage	Fall 00	3	7.32	7.53	2.36	5.28	9.98
Third cut mixed silage	Fall 99	2	6.91	6.91	2.99	4.79	9.02
Third cut mixed silage	Spring 00	1	6.15	6.15	N\A	6.15	6.15
Third cut mixed silage	June 00	1	7.05	7.05	N\A	7.05	7.05
Ryegrass silage	Spring 00	1	5.66	5.66	N\A	5.66	5.66
Ryegrass silage	August 00	1	9.83	9.83	N\A	9.83	9.83
Oatlage	Fall 99	1	6.90	6.90	N\A	6.90	6.90
First cut grain silage	Spring 00	1	2.87	2.87	N\A	2.87	2.87

Table F-2: Descriptive statistics pertaining hay bound protein and individual visit.

Hay	Visit	n	Median	Mean	Std. dev.	Min	Max.
First cut grass hay	Spring 00	1	16.31	16.31	N\A	16.3	16.31
First cut grass hay	June 00	3	15.71	13.00	N\A	6.98	16.31
First cut grass hay	Fall 00	3	8.63	10.44	4.64	6.98	15.71
Second cut grass hay	Fall 99	1	3.86	3.86	N\A	3.86	3.86
Second cut grass hay	September 00	1	11.80	11.80	N\A	11.8	11.80
Second cut grass hay	Fall 00	2	7.22	7.22	0.73	6.70	7.73
First cut mixed hay	Fall 99	1	9.44	9.44	N\A	9.44	9.44
First cut mixed hay	July 00	3	9.28	8.70	1.68	6.81	10.02
First cut mixed hay	August 00	1	12.13	12.13	N\A	12.1	12.13
First cut mixed hay	September 00	1	10.84	10.84	N\A	10.8	10.84
First cut mixed hay	Fall 00	6	9.69	10.54	3.96	7.00	17.46
First cut legume hay	Fall 00	1	14.94	14.94	N\A	14.9	14.94

Table F-3: Descriptive statistics pertaining to green chop bound protein and individual visit.

Green chop	Visit	n	Median	Mean	Std. dev.	Min	Max
Sorghum	August 00	1	5.08	5.08	N\A	5.08	5.08
Green chopped corn	August 00	1	8.21	8.21	N\A	8.21	8.21
Green chopped corn	September 00	1	9.16	9.16	N\A	9.16	9.16

Table F-4: Descriptive statistics pertaining to grain bound protein and individual visit.

Grain	Visit	n	Median	Mean	Std. dev.	Min.	Max.
Barley	Fall 99	1	1.49	1.49	N\A	1.49	1.49
Barley	Spring 00	1	1.49	1.49	N\A	1.49	1.49
Soy beans	Fall 00	1	3.55	3.55	N\A	3.55	3.55
Roasted soy beans	Fall 99	1	1.52	1.52	N\A	1.52	1.52
Roasted soy beans	Spring 00	1	1.52	1.52	N\A	1.52	1.52
Roasted soy beans	Fall 00	3	2.26	2.74	2.07	0.96	5.01

Table F-5: Descriptive statistics pertaining to corn silage bound protein and individual visit.

Visit	n	Median	Mean	Std. dev.	Min	Max
Fall 99	19	7.39	7.75	3.65	4.56	19.04
Spring 00	18	8.05	8.36	3.36	3.07	19.04
June 00	14	6.83	8.31	5.05	2.77	19.04
July 00	1	4.98	4.98	N\A	4.98	4.98
August 00	1	4.98	4.98	N\A	4.98	4.98
Fall 00	21	5.63	6.58	3.00	3.53	18.08

Table F-6: Descriptive statistics pertaining to pasture bound protein and individual sampling periods.

Sampling period	n	Median	Mean	Std. dev.	Min.	Max.
June 00	22	4.77	5.48	2.73	3.20	15.18
July 00	22	5.19	5.84	2.12	3.12	11.21
August 00	18	5.84	6.32	2.68	3.16	13.83
September 00	13	5.41	5.78	1.55	3.64	9.04

Appendix G
Acid Detergent Fiber (ADF)

Appendix G contains descriptive statistics pertaining to ADF levels in PEI feedstuffs fed during the study period.

Table G-1: Descriptive statistics pertaining to silage ADF and individual visit.

Forage	Visit	n	Median	Mean	Std. dev.	Min.	Max.
First cut grass silage	Fall 99	15	31.33	31.28	2.32	25.00	35.53
First cut grass silage	Spring 00	21	31.37	31.25	1.88	27.15	34.99
First cut grass silage	June 00	15	31.62	32.83	4.17	25.19	41.12
First cut grass silage	July 00	1	31.51	31.51	N\A	31.51	31.51
First cut grass silage	August 00	3	32.50	32.63	1.13	31.58	33.82
First cut grass silage	September 00	2	30.90	30.90	2.26	29.30	32.50
First cut grass silage	Fall 00	20	33.07	32.80	3.06	25.19	39.37
Second cut grass silage	Fall 99	3	32.21	32.22	0.46	31.77	32.69
Second cut grass silage	Spring 00	3	32.69	32.31	3.68	28.45	35.79
Second cut grass silage	June 00	2	33.88	33.88	1.57	32.77	34.99
Second cut grass silage	Fall 00	2	34.82	34.82	1.36	33.86	35.78
First cut mixed silage	Fall 99	53	30.79	30.89	2.54	23.96	36.17
First cut mixed silage	Spring 00	47	31.00	31.43	3.06	26.01	40.60
First cut mixed silage	June 00	27	31.85	32.89	4.47	25.45	44.86
First cut mixed silage	July 00	2	33.37	33.37	2.21	31.81	34.93
First cut mixed silage	August 00	5	30.73	30.90	2.82	27.22	34.93
First cut mixed silage	September 00	1	28.69	28.69	N\A	28.69	28.69
First cut mixed silage	Fall 00	45	33.06	33.06	3.67	26.10	41.20
Second cut mixed silage	Fall 99	15	30.64	31.24	2.88	26.43	35.41
Second cut mixed silage	Spring 00	7	33.54	33.14	2.32	30.11	35.89
Second cut mixed silage	June 00	3	31.87	31.02	3.56	27.11	34.07
Second cut mixed silage	Fall 00	3	32.50	32.94	1.47	31.75	34.58
Third cut mixed silage	Fall 99	2	28.73	28.73	0.97	28.04	29.41
Third cut mixed silage	Spring 00	1	27.24	27.24	N\A	27.24	27.24
Third cut mixed silage	June 00	1	28.47	28.47	N\A	28.47	28.47
First cut legume silage	Fall 99	13	27.10	28.01	3.25	22.90	33.68
First cut legume silage	Spring 00	13	30.53	31.28	4.13	25.82	37.43
First cut legume silage	June 00	9	30.54	31.12	3.53	26.84	36.20
First cut legume silage	July 00	2	31.59	31.59	5.59	27.64	35.54
First cut legume silage	Fall 00	15	34.03	34.23	4.37	28.20	41.02
Second cut legume silage	Fall 99	6	30.52	31.33	3.50	28.26	37.54
Second cut legume silage	Spring 00	3	31.78	31.72	1.01	30.68	32.69
Second cut legume silage	June 00	3	31.30	29.70	3.16	26.06	31.75
Second cut legume silage	Fall 00	2	32.84	32.84	3.41	30.43	35.25
Third cut legume silage	Fall 99	2	24.88	24.88	1.63	23.73	26.03
Third cut legume silage	Spring 00	1	23.73	23.73	N\A	23.73	23.73
Third cut legume silage	Fall 00	1	28.73	28.73	N\A	28.73	28.73
Ryegrass silage	Spring 00	1	27.87	27.87	N\A	27.87	27.87
Ryegrass silage	August 00	1	36.75	36.75	N\A	36.75	36.75
Oatlage	Fall 99	1	32.69	32.69	N\A	32.69	32.69

Table G-2: Descriptive statistics pertaining to hay ADF and individual visit.

Table G-2: Descriptive statistics pertaining to hay ADF and individual visit.

Hay	Visit	n	Median	Mean	Std. dev.	Min.	Max.
First cut grass hay	Fall 99	10	33.63	33.62	2.56	29.65	38.62
First cut grass hay	Spring 00	9	33.97	34.14	2.76	29.65	38.00
First cut grass hay	June 00	7	37.56	36.49	2.42	32.80	39.19
First cut grass hay	July 00	2	37.20	37.20	1.13	36.40	38.00
First cut grass hay	Fall 00	3	37.75	37.61	1.66	35.88	39.19
Second cut grass hay	Fall 99	2	32.70	32.70	0.18	32.57	32.82
Second cut grass hay	June 00	1	32.57	32.57	N\A	32.57	32.57
Second cut grass hay	September 00	1	37.05	37.05	N\A	37.05	37.05
Second cut grass hay	Fall 00	2	32.07	32.07	0.95	31.39	32.74
First cut mixed hay	Fall 99	11	34.32	34.39	2.68	30.97	38.98
First cut mixed hay	Spring 00	7	35.16	34.66	3.18	29.27	38.98
First cut mixed hay	June 00	8	32.60	32.93	2.28	30.03	35.66
First cut mixed hay	July 00	2	36.67	36.67	1.79	35.40	37.93
First cut mixed hay	August 00	2	36.20	36.20	1.13	35.40	37.00
First cut mixed hay	Fall 00	6	36.82	37.17	1.96	35.41	40.96
Second cut mixed hay	Fall 99	1	34.37	34.37	N\A	34.37	34.37
Second cut mixed hay	Spring 00	1	34.37	34.37	N\A	34.37	34.37
First cut legume hay	Fall 00	1	40.53	40.53	N\A	40.53	40.53

Table G-3: Descriptive statistics pertaining to green chop ADF and individual visit.

Green Chop	Visit	n	Median	Mean	Std. dev.	Min.	Max.
Green chopped corn	August 00	1	35.54	35.54	N\A	35.54	35.54
Green chopped corn	September 00	1	27.10	27.10	N\A	27.10	27.10
Green chopped ryegrass	September 00	1	27.34	27.34	N\A	27.34	27.34

Table G-4: Descriptive statistics pertaining to grain ADF and individual visit.

Grain	Visit	n	Median	Mean	Std. dev.	Min.	Max.
Barley	Fall 99	11	6.90	6.59	1.13	4.58	8.59
Barley	Spring 00	10	6.56	6.39	0.96	4.58	7.92
Barley	June 00	8	6.24	6.37	1.54	4.51	8.33
Barley	August 00	1	7.35	7.35	N\A	7.35	7.35
Barley	September 00	1	6.39	6.39	N\A	6.39	6.39
Barley	Fall 00	12	6.88	6.86	1.13	4.88	8.87
Wheat	Fall 99	1	3.72	3.72	N\A	3.72	3.72
Wheat	Spring 00	1	3.72	3.72	N\A	3.72	3.72
wheat	Fall 00	4	3.52	3.49	0.20	3.22	3.69
Oats	Fall 99	1	9.11	9.11	N\A	9.11	9.11
Oats	Spring 00	1	9.11	9.11	N\A	9.11	9.11
Soy bean	Fall 00	1	12.72	12.72	N\A	12.72	12.72
Roasted soy bean	Fall 99	3	9.69	8.64	3.57	4.66	11.57
Roasted soy bean	Spring 00	3	9.69	8.64	3.57	4.66	11.57
Roasted soy bean	June 00	1	13.91	13.91	N\A	13.91	13.91
Roasted soy bean	Fall 00	3	10.96	10.56	4.75	5.62	15.10

Table G-5: Descriptive statistics pertaining to pasture ADF and individual visit.

Visit	n	Median	Mean	Std. dev.	Min.	Max.
June 00	22	28.41	27.02	3.85	19.02	34.59
July 00	22	28.49	28.10	3.30	23.00	36.45
Summer 00(v3)	18	27.75	27.13	3.00	21.94	32.10
Summer 00(v4)	13	24.12	25.75	4.21	22.07	36.31

Table G-6: Descriptive statistics pertaining to corn silage ADF and individual visit.

Visit	n	Median	Mean	Std. dev.	Min.	Max.
Fall 99	19	23.74	23.50	2.75	19.19	29.24
Spring 00	18	22.63	23.58	3.69	19.19	34.37
June 00	14	22.92	22.53	2.35	15.68	26.13
July 00	1	22.19	22.19	N\A	22.19	22.19
Summer 00(v3)	1	22.19	22.19	N\A	22.19	22.19
Fall 00	21	23.48	24.35	3.21	19.19	32.84

Appendix H

Neutral Detergent Fiber (NDF)

Appendix H contains NDF descriptive statistics on the various PEI feedstuffs fed during the study

Table H-1: Descriptive statistics pertaining to forage NDF and individual visit.

Forage	Visit	n	Median	Mean	Std.dev.	Min.	Max.
First cut grass silage	Fall 99	13	51.94	52.08	4.50	40.01	59.03
First cut grass silage	Spring 00	21	51.67	52.88	4.48	43.33	61.30
First cut grass silage	June 00	16	54.01	54.20	7.11	41.02	66.21
First cut grass silage	July 00	1	53.56	53.56	N\A	53.56	53.56
First cut grass silage	August 00	3	55.32	55.92	2.25	54.03	58.40
First cut grass silage	September 00	2	54.02	54.02	1.85	52.71	55.32
First cut grass silage	Fall 00	20	53.92	54.52	5.17	45.17	64.75
Second cut silage	Fall 99	2	53.12	53.12	2.57	51.30	54.93
Second cut silage	Spring 00	2	50.36	50.36	7.81	44.84	55.88
Second cut silage	June 00	2	55.09	55.09	3.38	52.70	57.48
Second cut silage	Fall 00	2	56.44	56.44	1.07	55.68	57.20
First cut mixed silage	Fall 99	49	48.15	48.56	4.80	31.09	60.67
First cut mixed silage	Spring 00	44	48.16	47.38	4.47	38.15	57.73
First cut mixed silage	June 00	26	49.82	49.64	6.18	37.25	61.05
First cut mixed silage	July 00	2	53.50	53.50	5.41	49.67	57.32
First cut mixed silage	August 00	5	45.44	47.75	6.19	40.89	57.32
First cut mixed silage	September 00	1	49.97	49.97	N\A	49.97	49.97
First cut mixed silage	Fall 00	44	50.16	50.31	5.49	37.25	63.61
Second cut mixed silage	Fall 99	14	50.16	49.60	5.18	40.17	56.51
Second cut mixed silage	Spring 00	7	50.21	51.24	3.12	46.92	56.51
Second cut mixed silage	June 00	3	46.86	48.19	3.32	45.73	51.97
Second cut mixed silage	Fall 00	3	50.33	50.63	2.00	48.80	52.77
Third cut mixed silage	Fall 99	1	44.89	44.89	N\A	44.89	44.89
Third cut mixed silage	Spring 00	1	38.63	38.63	N\A	38.63	38.63
Third cut mixed silage	June 00	1	46.36	46.36	N\A	46.36	46.36
First cut legume silage	Fall 99	11	40.87	40.75	4.86	31.34	47.48
First cut legume silage	Spring 00	13	43.32	43.99	4.04	37.53	53.96
First cut legume silage	June 00	9	42.63	43.18	2.89	37.81	47.86
First cut legume silage	July 00	2	46.86	46.86	5.66	42.85	50.86
First cut legume silage	Fall 00	15	45.61	46.87	6.21	36.05	56.20
Second cut legume silage	Fall 99	5	45.30	45.32	3.51	41.35	50.56
Second cut legume silage	Spring 00	3	39.48	41.67	4.02	39.21	46.31
Second cut legume silage	June 00	3	41.72	43.69	4.17	40.87	48.48
Second cut legume silage	Fall00	2	45.20	45.20	7.06	40.20	50.19
Third cut legume silage	Fall 99	2	32.60	32.60	2.85	30.58	34.61
Third cut legume silage	Spring 00	1	34.61	34.61	N\A	34.61	34.61
Third cut legume silage	Fall 00	1	44.03	44.03	N\A	44.03	44.03
Ryegrass silage	Spring 00	1	46.50	46.50	N\A	46.50	46.50
Ryegrass silage	August 00	1	58.95	58.95	N\A	58.95	58.95
Oatlage	Fall 99	1	51.93	51.93	N\A	51.93	51.93

Table H-2: Descriptive statistics pertaining to hay NDF and individual visit.

Hay	Visit	n	Median	Mean	Std. dev.	Min.	Max.
First cut grass hay	Fall 99	8	60.56	60.72	3.67	54.65	66.79
First cut grass hay	Spring 00	7	59.03	60.43	4.00	54.65	67.30
First cut grass hay	June 00	6	62.74	63.07	3.81	59.03	67.57
First cut grass hay	July 00	2	61.83	61.83	0.18	61.70	61.96
First cut grass hay	Fall 00	3	63.59	64.08	3.27	61.08	67.57
Second cut grass hay	Fall 99	1	52.14	52.14	N\A	52.14	52.14
Second cut grass hay	June 00	1	65.83	65.83	N\A	65.83	65.83
Second cut grass hay	September 00	1	64.14	64.14	N\A	64.14	64.14
Second cut grass hay	Fall 00	2	57.97	57.97	3.96	55.17	60.77
First cut mixed hay	Fall 99	10	56.14	57.33	3.85	51.60	63.95
First cut mixed hay	Spring 00	6	57.70	57.37	6.01	47.31	63.95
First cut mixed hay	June 00	8	55.27	55.34	4.83	46.26	60.62
First cut mixed hay	July 00	2	61.03	61.03	0.57	60.62	61.43
First cut mixed hay	August 00	2	57.84	57.84	3.94	55.05	60.62
First cut mixed hay	Fall 00	6	57.85	57.96	3.17	53.13	62.46
Second cut mixed hay	Fall 99	1	57.57	57.57	N\A	57.57	57.57
Second cut mixed hay	Spring 00	1	57.57	57.57	N\A	57.57	57.57
First cut legume hay	Fall 00	1	55.97	55.97	N\A	55.97	55.97

Table H-3: Descriptive statistics pertaining to green chop NDF and individual visit.

Green Chop	Visit	n	Median	Mean	Std. dev.	Min.	Max.
Sorghum	August 00	1	59.68	59.68	N\A	59.68	59.68
Green chopped corn	Summer 00(v3)	1	51.85	51.85	N\A	51.85	51.85
Green chopped corn	September 00	1	44.96	44.96	N\A	44.96	44.96
Green chopped ryegrass	September 00	1	49.76	49.76	N\A	49.76	49.76

Table H-4: Descriptive statistics pertaining to corn silage NDF and individual visit.

Visit	n	Median	Mean	Std. dev.	Min.	Max.
Fall 99	16	41.78	41.22	4.75	33.75	47.79
Spring 00	18	38.87	40.54	4.60	34.86	49.56
June 00	14	38.26	40.22	9.77	27.60	71.56
July 00	1	38.41	38.41	N\A	38.41	38.41
August 00	1	38.41	38.41	N\A	38.41	38.41
Fall 00	21	41.90	43.23	8.00	34.51	71.56

Table H-5: Descriptive statistics pertaining to pasture NDF and individual visits.

Visit	n	Median	Mean	Stddev	Min.	Max.
June 00	22	53.23	52.30	5.85	42.15	63.96
July 00	22	50.46	51.11	5.85	40.47	64.47
August 00	18	50.28	48.21	5.62	33.68	54.71
September 00	13	45.88	45.20	7.88	30.25	59.92

Appendix I
Net Energy of Lactation (NE_l)

AppendixI contains NE_l descriptive statistics on the various PEI feedstuffs fed during the study

Table I-1: Descriptive statistics pertaining to silage NE_l and individual visit.

Silage	Visit	n	Median	Mean	Std. dev.	Min.	Max.
First cut grass silage	Fall 99	15	1.45	1.45	0.07	1.31	1.60
First cut grass silage	Spring 00	21	1.45	1.45	0.06	1.33	1.58
First cut grass silage	June 00	16	1.44	1.41	0.13	1.13	1.60
First cut grass silage	July 00	1	1.44	1.44	N\A	1.44	1.44
First cut grass silage	August 00	3	1.41	1.41	0.04	1.37	1.44
First cut grass silage	September 00	2	1.46	1.46	0.07	1.41	1.51
First cut grass silage	Fall 00	20	1.39	1.40	0.09	1.19	1.60
Second cut silage	Fall 99	3	1.42	1.42	0.01	1.40	1.43
Second cut silage	Spring 00	3	1.40	1.42	0.12	1.30	1.54
Second cut silage	June 00	2	1.37	1.37	0.05	1.33	1.40
Second cut silage	Fall 00	2	1.34	1.34	0.04	1.31	1.37
First cut mixed silage	Fall 99	53	1.44	1.43	0.07	1.29	1.55
First cut mixed silage	Spring 00	47	1.43	1.42	0.08	1.16	1.55
First cut mixed silage	June 00	27	1.41	1.38	0.12	1.04	1.55
First cut mixed silage	July 00	2	1.37	1.37	0.06	1.32	1.41
First cut mixed silage	August 00	5	1.44	1.43	0.08	1.32	1.54
First cut mixed silage	September 00	1	1.50	1.50	N\A	1.50	1.50
First cut mixed silage	Fall 00	45	1.37	1.37	0.10	1.15	1.55
Second cut mixed silage	Fall 99	15	1.44	1.42	0.08	1.31	1.55
Second cut mixed silage	Spring 00	7	1.36	1.37	0.06	1.30	1.46
Second cut mixed silage	June 00	3	1.41	1.43	0.10	1.35	1.54
Second cut mixed silage	Fall 00	3	1.39	1.38	0.04	1.33	1.41
Third cut mixed silage	Fall 99	2	1.50	1.50	0.03	1.48	1.51
Third cut mixed silage	Spring 00	1	1.54	1.54	N\A	1.54	1.54
Third cut mixed silage	June 00	1	1.50	1.50	N\A	1.50	1.50
First cut legume silage	Fall 99	13	1.49	1.47	0.07	1.35	1.55
First cut legume silage	Spring 00	13	1.42	1.40	0.09	1.27	1.52
First cut legume silage	June 00	9	1.42	1.41	0.08	1.29	1.50
First cut legume silage	Summer	2	1.40	1.40	0.12	1.31	1.48
First cut legume silage	Fall 00	15	1.34	1.34	0.10	1.19	1.47
Secondcut legume silage	Fall 99	6	1.42	1.40	0.08	1.26	1.47
Secondcut legume silage	Spring 00	3	1.39	1.39	0.02	1.37	1.42
Secondcut legume silage	June 00	3	1.40	1.44	0.07	1.39	1.52
Secondcut legume silage	Fall 00	2	1.37	1.37	0.07	1.31	1.42
Third cut legume silage	Fall 99	2	1.54	1.54	0.04	1.52	1.57
Third cut legume silage	Spring 00	1	1.57	1.57	N\A	1.57	1.57
Third cut legume silage	Fall 00	1	1.46	1.46	N\A	1.46	1.46
Ryegrass silage	Spring 00	1	1.56	1.56	N\A	1.56	1.56
Ryegrass silage	Summer (v3)	1	1.27	1.27	N\A	1.27	1.27

Table I-2: Descriptive statistics pertaining to hay NE_l and individual visit.

Hay	Visit	n	Median	Mean	Std. dev.	Min.	Max.
First cut grass hay	Fall 99	10	1.37	1.37	0.08	1.21	1.50
First cut grass hay	Spring 00	9	1.36	1.36	0.09	1.23	1.50
First cut grass hay	June 00	8	1.28	1.32	0.13	1.20	1.60
First cut grass hay	July 00 [a]	2	1.26	1.26	0.04	1.23	1.29
First cut grass hay	Fall 00	3	1.24	1.25	0.05	1.20	1.30
Second cut grass hay	Fall 99	2	1.40	1.40	0.01	1.40	1.41
Second cut grass hay	Summer 0	1	1.41	1.41	N\A	1.41	1.41
Second cut grass hay	September 00	1	1.26	1.26	N\A	1.26	1.26
Second cut grass hay	Fall 00	2	1.42	1.42	0.03	1.40	1.45
First cut mixed hay	Fall 99	11	1.34	1.34	0.08	1.21	1.43
First cut mixed hay	Spring 00	7	1.32	1.33	0.09	1.21	1.48
First cut mixed hay	Summer 0	8	1.39	1.38	0.06	1.30	1.46
First cut mixed hay	July 00	2	1.27	1.27	0.05	1.24	1.31
First cut mixed hay	August 00	2	1.29	1.29	0.03	1.26	1.31
First cut mixed hay	Fall 00	6	1.27	1.26	0.05	1.15	1.31
Second cut mixed hay	Fall 99	1	1.34	1.34	N\A	1.34	1.34
Second cut mixed hay	Spring 00	1	1.34	1.34	N\A	1.34	1.34

Table I-3: Descriptive statistics pertaining to grain NE_l and individual visit.

Grain	Visit	n	Median	Mean	Std. dev.	Min.	Max.
Barley	Fall 99	10	1.97	1.97	0.03	1.91	2.02
Barley	Spring 00	9	1.98	1.97	0.03	1.93	2.02
Barley	June 00	8	1.98	1.97	0.04	1.92	2.02
Barley	August 00	1	1.94	1.94	N\A	1.94	1.94
Barley	September 00	1	1.97	1.97	N\A	1.97	1.97
Barley	Fall 00	12	1.96	1.96	0.03	1.90	2.01
Wheat	Fall 99	1	2.05	2.05	N\A	2.05	2.05
Wheat	Spring 00	1	2.05	2.05	N\A	2.05	2.05
Wheat	Fall 00	4	2.05	2.05	0.01	2.05	2.06
Oats	Fall 99	1	1.89	1.89	N\A	1.89	1.89
Oats	Spring 00	1	1.89	1.89	N\A	1.89	1.89

Table I-4: Descriptive statistics pertaining to corn silage NE_l and individual visit.

Visit	n	Median	Mean	Std. dev.	Min.	Max.
Fall 99	19	1.61	1.61	0.04	1.55	1.67
Spring 00	18	1.63	1.62	0.04	1.49	1.67
June 00	14	1.63	1.63	0.03	1.59	1.71
July 00	1	1.63	1.63	N\A	1.63	1.63
Summer (v3)	1	1.63	1.63	N\A	1.63	1.63
Fall 00	21	1.61	1.60	0.06	1.38	1.67

Appendix J

Calcium

Table J-1: Frequency of PEI forages submitted during study and corresponding % calcium ranges. Forage species identification based on calcium levels Calcium Minimum and Maximum Levels Fall 99 - Fall 00.

Feedstuff	n	Min.	Max.
First cut grass silage	77	0.27	0.59
Second cut grass silage	10	0.34	0.59
First cut mixed silage	180	0.6	1.09
Second cut mixed silage	28	0.62	1.08
Third cut mixed silage	4	0.68	0.92
First cut legume silage	52	1.1	1.96
Second cut legume silage	14	1.11	2.74
Third cut legume silage	4	1.12	1.41
Ryegrass silage	2	0.41	0.62
Oatlage	1	0.59	0.59
First cut grain silage	1	0.4	0.4
First cut grass hay	31	0.21	0.58
First cut mixed hay	36	0.6	1.09
Second cut mixed hay	2	0.81	0.81
First cut legume hay	1	1.11	1.11
Green chop sorghum	1	0.67	0.67
Green chopped corn	2	0.21	0.36
Ryegrass green chop	1	0.51	0.51
Corn silage	74	0.1	3.14
pasture	75	0.25	2.48

Appendix K

Crude Protein

Appendix K : Contains descriptive statistics for crude protein on various NS feedstuffs fed during the study.

Table K-1: Descriptive statistics pertaining to NS stored forage crude protein for each visit.

Forage	Season	n	Median	Mean	Std. dev.	Min.	Max.
First cut grass silage	Fall 99	4	18.60	18.30	2.03	15.76	20.25
First cut grass silage	Spring 00	4	17.14	17.19	2.39	14.89	19.58
First cut grass silage	Summer 00	3	15.09	15.38	1.22	14.33	16.71
First cut grass silage	Fall 00	4	14.36	14.40	2.31	11.74	17.15
Second cut grass silage	Spring 00	1	17.84	17.84	N\A	17.84	17.84
Second cut grass silage	Summer 00	1	13.13	13.13	N\A	13.13	13.13
Second cut grass silage	Fall 00	1	18.36	18.36	N\A	18.36	18.36
First cut legume silage	Fall 99	1	18.54	18.54	N\A	18.54	18.54
First cut legume silage	Summer 00	2	19.36	19.36	2.11	17.87	20.85
Second cut legume silage	Fall 99	1	24.59	24.59	N\A	24.59	24.59
Second cut legume silage	Summer 00	1	19.23	19.23	N\A	19.23	19.23
First cut grass hay	Fall 99	1	13.62	13.62	N\A	13.62	13.62
Corn silage	Fall 99	7	9.46	10.70	4.09	7.59	19.77
Corn silage	Spring 00	9	9.19	9.01	0.93	7.92	10.48
Corn silage	Summer 00	6	9.15	8.85	0.72	7.92	9.69
Corn silage	Fall 00	7	9.03	8.90	0.64	7.79	9.69
First cut mixed silage	Fall 99	4	18.80	17.97	2.23	14.69	19.57
First cut mixed silage	Spring 00	4	18.62	17.94	2.17	14.84	19.7
First cut mixed silage	Summer 00	1	20.78	20.78	N\A	20.78	20.78
First cut mixed silage	Fall 00	4	18.94	18.47	2.34	15.24	20.75

Table K-2: Descriptive statistics pertaining to NS grain crude protein for each visit.

Grains	Visit	n	Median	Mean	Std. d.	Min.	Max.
Roasted soya beans	Fall 99	1	32.85	32.85	N\A	32.85	32.85
High moisture corn	Fall 99	2	9.92	9.92	0.83	9.33	10.51
High moisture corn	Spring 00	2	9.92	9.92	0.83	9.33	10.51
High moisture corn	Summer00	2	9.01	9.01	2.12	7.51	10.51
High moisture corn	Fall 00	2	9.63	9.63	1.75	8.39	10.87
High moisture ear corn	Fall 99	1	8.69	8.69	N\A	8.69	8.69
High moisture ear corn	Spring 00	2	8.32	8.32	1.19	7.48	9.16

Appendix L

Soluble Protein

Appendix L contains descriptive statistics pertaining to soluble protein levels in NS feedstuffs fed during the study period.

Table L-1: Descriptive statistics pertaining to NS stored forage soluble protein values on each visit.

Forage	Visit	n	Median	Mean	Std. de	Min.	Max.
First cut grass silage	Fall 99	4	56.06	57.08	5.78	51.53	64.67
First cut grass silage	Spring 00	4	60.94	62.51	5.15	58.25	69.90
First cut grass silage	Summer 00	3	62.26	56.75	11.05	44.03	63.96
First cut grass silage	Fall 00	4	63.44	62.08	5.10	54.87	66.57
Second cut grass silage	Spring 00	1	60.51	60.51	N/A	60.51	60.51
Second cut grass silage	Summer 00	1	59.06	59.06	N/A	59.06	59.06
Second cut grass silage	Fall 00	1	45.09	45.09	N/A	45.09	45.09
First cut legume silage	Fall 99	1	43.30	43.30	N/A	43.30	43.30
First cut legume silage	Summer 00	2	42.77	42.77	16.15	31.35	54.19
Second cut legume silage	Fall 99	1	44.26	44.26	N/A	44.26	44.26
Second cut legume silage	Summer 00	1	49.34	49.34	N/A	49.34	49.34
Corn silage	Fall 99	7	43.79	41.54	19.71	48.44	56.46
Corn silage	Spring 00	9	53.92	54.45	5.72	44.36	60.97
Corn silage	Summer 00	6	55.67	57.28	9.53	45.07	71.81
Corn silage	Fall 00	7	55.31	55.18	8.75	41.27	66.79
First cut mixed silage	Fall 99	4	57.57	56.57	5.94	48.81	62.31
First cut mixed silage	Spring 00	4	59.09	58.53	1.70	56.04	59.90
First cut mixed silage	Summer 00	1	50.80	50.80	N/A	50.80	50.80
First cut mixed silage	Fall 00	4	61.16	59.99	6.29	51.35	66.31

Appendix M

Bound Protein

Appendix M contains descriptive statistics pertaining to bound protein levels in NS feedstuffs fed during the study period

Table M-1: Descriptive statistics pertaining to NS stored forage bound protein values on each visit.

Forage	Season	n	Median	Mean	Std. dev	Min.	Max.
First cut grass silage	Fall 99	4	5.26	7.50	5.04	4.43	15.03
First cut grass silage	Spring 00	4	5.26	6.04	1.92	4.78	8.88
First cut grass silage	Summer 00	3	3.41	3.71	0.84	3.06	4.66
First cut grass silage	Fall 00	4	5.36	4.95	1.45	2.87	6.22
Second cut grass silage	Spring 00	1	6.32	6.32	N/A	6.32	6.32
Second cut grass silage	Summer 00	1	4.72	4.72	N/A	4.72	4.72
Second cut grass silage	Fall 00	1	9.44	9.44	N/A	9.44	9.44
First cut legume silage	Fall 99	1	6.34	6.34	N/A	6.34	6.34
First cut legume silage	Summer 00	2	7.81	7.81	2.38	6.12	9.49
Second cut legume silage	Fall 99	1	9.09	9.09	N/A	9.09	9.09
Second cut legume silage	Summer 00	1	7.15	7.15	N/A	7.15	7.15
Corn silage	Fall 99	7	4.83	4.93	2.56	0.00	8.31
Corn silage	Spring 00	9	5.41	5.94	1.04	4.82	8.05
Corn silage	Summer 00	6	5.05	4.67	1.40	2.68	6.50
Corn silage	Fall 00	7	5.36	5.19	1.10	3.70	6.68
First cut mixed silage	Fall 99	4	4.80	4.82	1.20	3.44	6.25
First cut mixed silage	Spring 00	4	5.17	5.34	0.94	4.38	6.63
First cut mixed silage	Summer 00	1	4.88	4.88	N/A	4.88	4.88
First cut mixed silage	Fall 00	4	5.64	6.06	1.73	4.64	8.32

Appendix N

Acid Detergent Fiber (ADF)

Appendix N contains descriptive statistics pertaining to ADF levels in NS feedstuffs fed during the study period.

Table N-1: Descriptive statistics pertaining to NS stored forage ADF values on each visit.

Forage	Season	n	Median	Mean	Std. dev.	Min.	Max.
First cut grass silage	Fall 99	4	31.17	31.12	2.58	28.00	34.14
First cut grass silage	Spring 00	4	31.76	31.64	3.07	27.76	35.26
First cut grass silage	Summer 00	3	31.97	32.35	0.91	31.69	33.39
First cut grass silage	Fall 00	4	31.72	32.63	3.04	30.24	36.84
Second cut grass silage	Spring 00	1	33.40	33.40	N/A	33.40	33.40
Second cut grass silage	Summer 00	1	33.05	33.05	N/A	33.05	33.05
Second cut grass silage	Fall 00	1	33.41	33.41	N/A	33.41	33.41
First cut legume silage	Fall 99	1	29.38	29.38	N/A	29.38	29.38
First cut legume silage	Summer 00	2	30.94	30.94	2.03	29.50	32.37
Second cut legume silage	Fall 99	1	27.09	27.09	N/A	27.09	27.09
Second cut legume silage	Summer 00	1	30.29	30.29	N/A	30.29	30.29
First cut grass hay	Fall 99	1	33.20	33.20	N/A	33.20	33.20
Corn silage	Fall 99	7	20.40	17.26	8.58	0.00	24.35
Corn silage	Spring 00	9	22.34	22.13	3.95	17.55	29.42
Corn silage	Summer 00	6	20.06	22.04	4.36	18.16	29.42
Corn silage	Fall 00	7	22.25	22.26	3.22	17.23	26.88
First cut mixed silage	Fall 99	4	31.17	31.34	1.46	29.84	33.19
First cut mixed silage	Spring 00	4	33.76	33.19	2.40	29.84	35.42
First cut mixed silage	Summer 00	1	29.47	29.47	N/A	29.47	29.47
First cut mixed silage	Fall00	4	30.73	30.79	3.68	27.12	34.59

Appendix O

Neutral Detergent Fiber (NDF)

Appendix O contains descriptive statistics pertaining to NDF levels in NS feedstuffs fed during the study period.

Table O-1: Descriptive statistics pertaining to NS stored forage NDF values on each visit.

Forage	Season	n	Median	Mean	Std. dev	Min.	Max.
First cut mixed silage	Fall 99	4	47.86	46.36	4.60	39.92	49.80
First cut mixed silage	Spring 00	4	48.52	49.37	4.54	45.33	55.12
First cut mixed silage	Summer 00	3	50.36	50.30	3.64	46.63	53.91
First cut mixed silage	Fall 00	4	49.06	51.36	6.91	45.89	61.42
Second cut grass silage	Spring 00	1	48.95	48.95	N/A	48.95	48.95
Second cut grass silage	Summer 00	1	51.47	51.47	N/A	51.47	51.47
Second cut grass silage	Fall 00	1	51.69	51.69	N/A	51.69	51.69
First cut legume silage	Fall 99	1	41.83	41.83	N/A	41.83	41.83
First cut legume silage	Summer 00	2	38.49	38.49	3.19	36.23	40.74
Second cut legume silage	Fall 99	1	39.97	39.97	N/A	39.97	39.97
Second cut legume silage	Summer 00	1	40.78	40.78	N/A	40.78	40.78
First cut grass hay	Fall 99	1	61.41	61.41	N/A	61.41	61.41
Corn silage	Fall 99	7	36.85	30.62	15.02	0.00	40.90
Corn silage	Spring 00	9	38.49	38.62	6.10	31.23	49.17
Corn silage	Summer 00	6	34.43	37.47	6.32	32.69	49.17
Corn silage	Fall 00	7	36.67	37.95	5.64	28.03	45.19
First cut mixed silage	Fall 99	4	47.97	47.72	2.29	44.73	50.23
First cut mixed silage	Spring 00	4	49.34	49.54	4.10	44.73	54.74
First cut mixed silage	Summer 00	1	39.37	39.37	N/A	39.37	39.37
First cut mixed silage	Fall 00	4	46.43	45.53	4.69	39.08	50.17

Appendix P

Net Energy of Lactation (NE_l)

Appendix P contains descriptive statistics pertaining to NE_l levels in NS feedstuffs fed during the study period.

Table P-1: Descriptive statistics pertaining to NS stored forage NEl_l values on each visit.

Forage	Season	n	Median	Mean	Std. dev.	Min.	Max.
First cut grass silage	Fall 99	4	1.46	1.45	0.09	1.34	1.55
First cut grass silage	Spring 00	4	1.42	1.42	0.09	1.31	1.52
First cut grass silage	Summer 00	3	1.40	1.40	0.04	1.37	1.44
First cut grass silage	Fall 99	4	1.41	1.39	0.08	1.27	1.45
Second cut grass silage	Spring 00	1	1.36	1.36	N/A	1.36	1.36
Second cut grass silage	Summer 00	1	1.37	1.37	N/A	1.37	1.37
Second cut grass silage	Fall 00	1	1.36	1.36	N/A	1.36	1.36
First cut legume silage	Fall 99	1	1.48	1.48	N/A	1.48	1.48
First cut legume silage	Summer 00	2	1.42	1.42	0.04	1.39	1.44
Second cut legume silage	Fall 99	1	1.58	1.58	N/A	1.58	1.58
Second cut legume silage	Summer 00	1	1.42	1.42	N/A	1.42	1.42
First cut grass hay	Fall 99	1	1.37	1.37	N/A	1.37	1.37
Corn silage	Fall 99	7	1.64	1.42	0.63	0.00	1.76
Corn silage	Spring 00	9	1.63	1.64	0.05	1.55	1.69
Corn silage	Summer 00	6	1.66	1.64	0.05	1.55	1.68
Corn silage	Fall 00	7	1.63	1.63	0.04	1.58	1.69
First cut mixed silage	Fall 99	4	1.43	1.43	0.03	1.39	1.46
First cut mixed silage	Spring 00	4	1.37	1.38	0.06	1.31	1.46
First cut mixed silage	Summer 00	1	1.47	1.47	N/A	1.47	1.47
First cut mixed silage	Fall 00	4	1.44	1.44	0.10	1.33	1.54

Appendix Q
Forage availability

Table Q-1: Individual herd minimal forage mass availability (kg of dry matter) and requirements (kg of dry matter).

Herd	June visit kg DM	June requirement kg DM	July kg DM	July requirement kg DM	August kg DM	August requirement kg DM
1	31239	617	38129	653	.	
2					23020	754
3	9825	933			14545	243
4	5050	537	10595	501	10155	510
5	3542	376	2317	125	1987	57
6			10265	1705	61075	1577
7			30430	510	28890	122
8	33064	576	Rye	N/A	Rye	N/A
9	12015	1506	13345	1630		
10 am	117260	1068	28976	819	14694	757
10 pm	11128	1068	11556	819	Rye	N/A
11					Rye	N/A
12 am	.		9342	171	Rye	N/A
12 pm	.		Rye	N/A	8726	187
13	9480	275	9605	268		
13 am					Rye	N/A
13 pm					11915	123
14 am			17070	534	Rye	N/A
14 pm			15222	534	9440	289
15			37960	1973	42380	1477
16 am	25050	502	10872	547		
16 pm	11526	502	Rye	N/A		
17	10960	748	11145	799	7185	337
18			11908	826	9976	696

Appendix R
Milk production estimates

Table R-1: Summer 2000, PEI individual herd average milk production estimates for early, mid- and late lactation cows.

Note: Heifers and production values that were below the 50 th percentile were excluded from the mean production estimates.

HERD	DIM 50	DIM 120	DIM 200
1	34.58	34.07	25.67
2	28.79	24.33	18.04
3	35.89	30.49	23.08
4	35.66	32.11	23.51
5	36.12	32.5	24.85
6	39.04	29.97	21.63
7	43.15	36.02	23.01
8	36.41	31.57	24.41
9	37.62	35.01	26.57
10	34.13	29.36	21.56
11	33.47	28.08	18.62
12	33.42	31.13	21.82
13	45.36	39.76	29.96
14	33.85	33.27	26.69
15	39.87	32.95	24.2
16	31.64	28.26	21.59
17	40.85	31.8	25.07
18	28.01	23.74	19.81