THE INTEGRATION OF DAIRY PRODUCTION, HEALTH AND FOOD SAFETY INFORMATION

A Thesis

Submitted to the Graduate Faculty

in Partial Fulfilment of the Requirements

for the Degree of

Master of Science

in the Department of Health Management

Faculty of Veterinary Medicine

University of Prince Edward Island

S.Craig Bellamy

Charlottetown, P.E.I.

March, 1994

ISBN 0-315-88453-3

The author has agreed that the Library, University of Prince Edward Island, may make this thesis freely available for inspection. Moreover the author has agreed that permission for extensive copying of this thesis for scholarly purposes may be granted by the professor or professors who supervised the thesis work recorded herein or, in their absence, by the Chairman of the Department or the Dean of the Faculty in which the thesis work was done. It is understood that due recognition will be given to the author of this thesis and to the University of Prince Edward Island in any use of the material in this thesis. Copying or publishing or any other use of the thesis for financial gain without the approval by the University of Prince Edward Island and the author's written permission is prohibited.

Requests for permission to copy or to make other use of material in this thesis in whole or in part should be addressed to:

Chairman of the Department of Health Management

Faculty of Veterinary Medicine

University of Prince Edward Island

Charlottetown, P.E.I.

Canada C1A 4P3

SIGNATURE PAGES

iii-iv

REMOVED

ABSTRACT

A study was conducted in P.E.I. to determine the feasibility of establishing a network of communication to monitor basic herd level animal health, productivity and food safety on dairy farms. A basic herd level system (HERD) which collected only herd level data and collected all data directly from the farm, was compared to an animal level system (ANIMAL) that collected animal and herd level data from various sources. A random sample of 12 dairy farms participated from September 1, 1991 to August 31, 1992.

The HERD system required minimal infrastructure and was therefore simpler to implement, had limited data to enter, was not dependent on farmer participation in other programs such as dairy herd improvement (and hence was available to all producers), and could compare one producer's performance to others. The HERD system had disadvantages including: ongoing resources required to make regular contact with many individual producers, no direct contact with private veterinary practitioners, no animal level data to assist producers with individual animal management decisions, limited data validation, limited reproductive data, few analyses possible, and poor compliance by producers.

The ANIMAL system required a complex infrastructure, was limited to DHI participants, required limitations on the commercial animal health software that could be supported, and had no direct contact with producers. The ANIMAL system, however, utilized sophisticated health management software available, provided more data validation and hence more reliable data, provided extensive analysis and reporting which resulted in increased compliance, and provided increased contact between private and public veterinarians.

Additional food safety monitoring was done on participating farms. Bulk-tank bacteriology testing was increased from bi-weekly to weekly samples. This increased frequency did show isolated counts higher than normal for particular farms. Samples were also screened for antimicrobial residue using the disc assay. All results were negative. Samples were tested using the LacTek sulfamethazine and β-lactam tests. Five bulk-tank samples were positive, however, bulk-tank milk was sufficiently diluted with other milk in the truck, that residue was undetectable in 4 of the 5 corresponding truck samples.

Participants were asked to identify, with a particular ear tag, all cull cows leaving the farm. Only 10 of 92 cows culled were tagged on leaving the farm. This low compliance indicates a voluntary animal identification system would not enable the tracing of positive meat residue test results from slaughter to the farm of origin.

Predictive models were developed that used dairy farm facilities and sanitation scores, as scored by the P.E.I. Department of Agriculture inspectors, for the prediction of bulk-tank somatic cell counts and high bulk-tank bacterial counts. Models were developed using data from 1989 to 1991 then validated by applying the models to 1992 data. Sanitation levels of dairy barns and equipment were significant predictors of average bulk-tank SCC. The model performed as well predicting bulk-tank SCC with new data as it did with the original data. The sanitation of equipment was the only significant predictor of high bulk-tank bacterial counts. Although the annual inspection scores were statistically significant predictors, they did not make good predictors of annual average bulk-tank SCC or high bacterial counts.

ACKNOWLEDGEMENTS

I thank Dr. Ian Dohoo for his supervision and advice throughout this study. He has managed to teach this old dog some new tricks. I thank Dr. Liz Spangler for her direction during Dr. Dohoo's year abroad. I also thank the other members of my supervisory committee, Drs. Bruce McNab, Mark Novotny, Tim Ogilvie and Pam Ruegg for their time and commitment to this project. Three additional individuals, Drs. Alan Donald, Larry Heider and Ray Long were members of my examination committee. I thank them for the time and interest given to my program.

The participating dairy producers deserve a special thank you. The kindness, cooperation and willingness of all dairy farmers not only made the data collection possible but made it one of the more enjoyable parts of the project. The effort and interest of Judy Clinton, when asked to retrieve data from the APHIN central database, was greatly appreciated. Thanks to Ellen Bannister who assisted with data entry. The P.E.I. Provincial Dairy Laboratory management and staff were more than accommodating and went out of their way to ensure the extra sampling and testing was done. Thanks also to Dr. Dave Kelton, Ontario Veterinary College, for providing a copy of his ODMAP program and allowing me to modify it for this project. Considerable programming time was saved.

This project also involved the cooperation of the Atlantic Veterinary College and APHIN personnel, Agriculture Canada Food Production and Inspection Branch (especially the Charlottetown Animal Health District Office), and the private veterinary practitioners who worked with the participating producers on a regular basis. Thank you to all those involved. A special thanks to Agriculture Canada for the opportunity and financial support that made this project possible.

To my wife, Judy, I express my love and most heart felt gratitude for her understanding and encouragement. I am sure she thought it enough with our children, Susan, Heather and Deanna attending university and Tim in high school, without having to put up with me as a student again. Judy does, however, have the opportunity to attend three different convocations in the spring of 1994, one each for Susan, Heather and myself.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

Historically in Canada, publicly funded veterinary programs for animal health and food safety have dealt primarily with zoonotic diseases and meat hygiene. These programs have been very successful. Notable examples include the brucellosis, tuberculosis and meat inspection programs.

Notwithstanding these successes, new concerns continue to challenge the system. It is a period of rapid change and evolution in the animal-derived food industry. Consumers are concerned more than ever about their health and well-being, particularly as they are affected by food products. The safety, both real and perceived, of animal-derived food products is a major concern of consumers, public health officials and veterinarians (1,2,3,4,5,6). Consumers wants to feel confident that their food is wholesome and pure.

Farmers are also concerned about the safety of the food they produce (7). They realize consumers are more and more sceptical about the safety of this food. As a result, it is no longer sufficient to merely produce safe food; there is also the requirement to demonstrate the safety of their products and to illustrate the differences between negative public perceptions concerning food production and the positive realities of the system that exists within a safe, humane, and sustainable environment.

Along with these new challenges come new opportunities. The agri-food industry now has the opportunity to capitalize on current public concern, to invest pro-actively in systems that insure and demonstrate that food is consistently produced in a safe, humane and sustainable manner. Advances in computer technology provide an opportunity to capture, summarize and analyze crucial data that are needed to address this concern.

Currently, there exists an infrastructure of:

a) producers who are a source of data concerning animal health, welfare and production, but who need the data summarized and analyzed to support more efficient production, better marketing and improved public relations,

b) veterinary practitioners who have access to this information from producers, but who need the skills and financial reimbursement to capture, summarize, interpret and pass on the information,

c) regulatory veterinarians who have a strong infrastructure of district, abattoir, import/export, laboratory, regional and national personnel, but who need a mechanism that will better facilitate a two way flow of information along the entire food chain,

d) universities which have expertise in research and training, but which require field data to use in research and training, and finally

e) society in general, which supports and needs food production that is conducted in a safe, healthy, humane and sustainable manner.

A logical next step is to collate the strengths and needs of the members of this infrastructure into an Animal Health and Food Safety Epidemiology Network (AHFSEN), which could be used as a mechanism to facilitate and promote health for livestock and humans. The mission of AHFSEN would be to promote animal health in support of the efficient sustainable production of safe, high quality animal origin foods and products within Canada.

A basic proposal for an AHFSEN Research Plan, presented by Dr. W.B. McNab and Dr. A.H. Meek, was supported by the Expert Committee on Animal Health at the November 1990 meeting. The proposed research was to be conducted in three distinct phases.

The subject of this thesis is the result of the first phase. The objectives of phase one were:

a) to investigate the feasibility of establishing a network of communication involving randomly selected producers, private veterinarians, regulatory veterinarians and industry groups to monitor basic herd level animal health, production and food safety on dairy farms,

b) to obtain preliminary data concerning the monetary cost, from the societal point of view, of establishing and maintaining a network to monitor animal health and food safety at the farm level and to include a comparison of record keeping systems operating at the herd and individual animal levels,

c) to develop and test the feasibility of establishing basic farm level monitors of milk and meat food safety, and

d) to analyze Provincial Dairy Inspection Report data and Provincial Dairy Laboratory data, from all dairy farms in P.E.I., in an attempt to identify herd management factors that predict milk quality and safety.

The proposed second phase is a pilot study to implement an information system used in phase one and investigate the feasibility and costs associated with implementing the system in an area geographically separate from the original study. If this phase is successful then the system may be gradually expanded to include a broader geographic base as part of the overall AHFSEN.

The proposed third phase is a separate study to be conducted on P.E.I. It will use the APHIN system to develop and verify indices that measure food safety at the farm level. Such indices may later be incorporated into a herd level AHFSEN system. The need for such indices is based on the assumption that the farm is recognized as the first critical control point along the food chain, and the development and use of such indices have the potential to contribute greatly to the overall goal of food production being conducted in a safe, healthy and sustainable manner.

1.2 AHFSEN - Feasibility Study

Notwithstanding the concerns of producers as expressed above, one major objective for dairy farmers is to produce milk at the lowest possible cost. Opportunities exist for improving profitability with the development and use of accurate and efficient herd management systems for monitoring production and health. The incorporation of food safety information into these systems would help to meet both needs, improving efficiency and improving and demonstrating safety.

Microcomputer based systems have been developed and used in the dairy industry since the early 1970's. These systems have focused on production and animal health, with little emphasis on food safety. They support operational functions by producing lists of animals due to calve or dry off, etc., they monitor production parameters to help identify areas of operations not meeting targets, and they provide some evaluation tests to help identify reasons for failure to meet these production targets. With continued improvements and versatility of computerized dairy herd health and production management software there has been increased utilization by the dairy industry (8,9). Advances made in the quality and performance of computer hardware and the significant reductions in their cost have made these systems accessible to all producers. Accurate and manageable recording systems now play an essential role in progressive dairy health management programs. Many veterinarians and producers are using sophisticated microcomputer-based dairy herd management software to monitor and perform detailed analyses of the health and productivity of the farm (10,11,12).

Most of these systems are designed for use on the farm to monitor individual cows as well as the herd and to provide information to producers and their advisors to facilitate better management decisions. These programs are currently being integrated into decision support systems which may also contain simulation models and expert systems (13,14,15).

There is often a need to collate information within a geographic area. Several systems have the capability to make comparisons between farms and easily amalgamate data from various sources or geographic regions. Such systems are very useful for field research to investigate diseases and their impacts on production (16,17,18).

Dairy Herd Improvement (DHI) programs were the original computer-assisted dairy herd management systems. Animal identification, performance status, and some measures of resources are collected monthly and sent to the DHI center for computation. Reports, returned by mail to the dairy manager, summarize individual animal status, overall performance and some of the costs of production. The DHI programs in Canada and the United States have had considerable growth since their inception and have become significant information management systems (19).

Other systems have since been developed with field research in mind. One of these, the system called FAHRMX (Farm Animal Health Resource Management System) was initiated at the College of Veterinary Medicine, Michigan State University, in 1979 in response to a need for a comprehensive, integrated record-keeping system to aid veterinarians and dairy managers in the operation of an ongoing herd health program (20). With FAHRMX, data from several farms in a geographic area was collected and analyzed. FAHRMX was developed to be applicable to the need for epidemiologic and economic research into disease and production problems in the dairy industry (16). DairyMisII is a dairy herd management system that has been implemented on dairy farms in Ireland since 1980. This system compares performance of participating farms with that of other farms in the group (21). The general objective of the National Animal Health Monitoring System (NAHMS) coordinated by the United States Department of Agriculture is to develop methods for estimating accurately the prevalence, incidence, trends, and economic impact of diseases in food-producing animals in the United States (18). In 1988, a computerized health and production information network (APHIN: Animal Productivity and Health Information Network) was established in Prince Edward Island to collate and analyze data from multiple sources on a regular basis including farms, veterinary practices, abattoir, Provincial Milk Quality Laboratory, Provincial Diagnostic Laboratory, and the Atlantic Dairy Livestock Improvement Corporation (ADLIC) (17). This system increases the availability of health and productivity information in the swine, dairy and beef industries, making information available to producers, veterinarians, extension workers, researchers and others involved in livestock production. APHIN is a service-oriented system that consists of a number of microcomputers on farms, in veterinary practices, in the processing industry and in laboratories linked to a central database located at the Atlantic Veterinary College. In general, the microcomputers operate independently of the central computer and meet most or all of the user's local information processing needs. Relevant data are extracted from files stored in the microcomputers, transmitted to the central database on microcomputer diskettes or magnetic tapes for collation, analysis, summarization and distribution to users.

With the exception of NAHMS, the above systems are based on individual cow data. The Ontario Dairy Monitoring and Analysis Program (ODMAP) collects individual and herd level data but stores only herd level data (22). This system monitors the performance of the herd, not the individual animal within the herd, and reports the performance compared to that of other herds participating in the system. As with APHIN, the system makes use of existing data whenever possible, collecting information directly from third party sources. Currently these data must be re-entered and stored in a central database at the Ontario Veterinary College.

With the increased use of computerized health management programs and information systems, the opportunity exists to integrate these systems into a regional and national network. This study evaluated a herd level system and an individual animal based system, to determine if either would be suitable for use as a basis for a national surveillance system. Results of this evaluation are presented in Chapters 2 and 3.

1.3 AHFSEN - Analysis of Dairy Inspection Scores

Although this study was done as part of the first phase of the three phased AHFSEN proposal, it was a small start for phase three. The farm is an early critical point along the food chain, and as such, a desirable level to start controlling milk quality and safety. The ability to predict bulk-tank somatic cell counts, bacterial counts and the presence of antimicrobial residue before the milk leaves the farm would assist in this control. The study examined the predictive ability of dairy farm facility and sanitation scores, as scored by the Prince Edward Island Department of Agriculture inspectors, for the prediction of these bulk-tank milk quality and safety parameters. Results of this study are presented in Chapter 4.

2. A FEASIBILITY STUDY: THE BASE FOR A NATIONAL ANIMAL PRODUCTIVITY, HEALTH AND FOOD SAFETY EPIDEMIOLOGY NETWORK

2.1 Introduction

With the increased use of computerized health management programs and information systems, the opportunity exists to incorporate food safety and quality information into these systems and integrate these systems into a regional and national network. A comprehensive regional or national food animal health, production and food safety surveillance system would allow agriculture to better utilize epidemiologic and technologic advances. Such information could be used to help validate or certify sound production practices and ensure consumer confidence.

The objectives of this chapter are to describe and discuss two approaches to monitoring dairy production, health and food safety, one approach involving the collection of *exclusively herd level data solely from the farm* (HERD), the second involving *individual and herd level data collection directly from various sources* (ANIMAL).

Specific objectives are: 1) to describe the two systems in detail, 2) to discuss validation of the data in the systems, 3) to compare data collection efforts for the two approaches, 4) to discuss the value of the two approaches to producers, veterinarians and Agriculture Canada.

2.2 Materials and Methods

2.2.1 Computer Programs Used

Three existing computer applications were utilized for this study. They were the Ontario Dairy Monitoring and Analysis Program (ODMAP) (22), the dairy portion of the Animal Productivity and Health Information System (APHIN) (23) and DairyChamp (24).

2.2.1.1 ODMAP

The Ontario Dairy Monitoring and Analysis Program was a computer program developed as part of a study starting in early 1990. The study was undertaken by the Department of Population Medicine, Ontario Veterinary College to investigate the relationships among herd-level measures of disease, management, production, reproductive performance and profitability in Ontario dairy herds (22). Participants included the University researchers, 27 private practitioners plus 113 producers purposively selected by the practitioners from among their clients.

The data collection system attempted to make use of existing data whenever possible. Ontario DHI production and somatic cell count reports were mailed directly to the researchers and financial information was obtained through the Ontario Farm Management Analysis Project. On-farm data were collected using collection sheets on the farm or from existing on-farm computerized record systems. Individual animal reproductive performance, clinical disease, culling and youngstock management data were recorded on the data sheets by the producer and forwarded monthly to the Ontario Veterinary College. Some individual animal data were summarized manually on the data collection sheets and entered as herd level data, some reproductive data were entered as individual animal data, analyzed and summarized by the program, then transferred to the herd level database for storage. All data were manually entered into a central database at the Ontario Veterinary College. This central database and supporting programs were developed using the database management software dBase IV (25).

Every three months reports were produced summarizing the performance of the herd for the preceding 12 month period. Information was presented in table and graphical format and included comparisons with the performance of other herds participating in ODMAP.

2.2.1.2 APHIN

The dairy portion of APHIN has been described (23). It consists of microcomputers on farms, in veterinary practices, in the PEI Department of Agriculture (PEIDA) laboratories and offices, and within the Atlantic Veterinary College (AVC), operating independently of the central computer located at AVC. These microcomputers meet most or all of the user's local needs and serve as a source of data for APHIN or may process information distributed by APHIN.

APHIN currently incorporates three sources of dairy data. The first source is all six food animal veterinary practices in PEI that offer the computerized health management program DairyCHAMP to process their clients records. Approximately

50 producers have enrolled on this service to date. Each month the individual cow data, including records of reproductive events, disease occurrences and examination results, are sent from the microcomputers in the clinics to APHIN.

The second data source is ADLIC. Data on magnetic tape, including individual cow milk test weights and somatic cell count (SCC), are provided monthly for all herds enrolled on ADLIC.

The third source is the Provincial Milk Quality Laboratory which provide data on bulk-tank SCC, standard plate count and other milk quality parameters for bulk-tank samples from all commercial milk producers in P.E.I.

All data received by APHIN are collated with data already in the database. Once a month, programs analyze all the data from participating farms to update tables summarizing milk production performance, reproductive performance and milk quality. One record per herd per month is created containing all the key production parameters. The provincial average and 25th, 50th and 75th percentiles are also included in the table.

Veterinary practitioners and some extension specialists are sent, on a monthly basis, ASCII files containing the data from herds for which they have permission to receive data. These summary data files are converted into graphs of performance using a preprogrammed Lotus (26) spreadsheet. The graphs can have the herd data, comparison group data, a herd specific target and a regression line through the herd's data. A list of the health and production parameters currently being monitored and available for users is included (Appendix D).

2.2.1.3 DairyCHAMP

The DairyCHAMP program is a dairy cow management microcomputer program produced at the University of Minnesota that helps daily animal management, herd performance monitoring and problem analysis (27). It has a modular design with six main components: input creates or updates the data, output generates information from the data, data storage is the interface between input and output, file management tracks data files to ensure they are intact and operational, farm parameters allow the input and output procedures to be customized to particular farms, system parameters customize the program to particular hardware and allow adjustments of the user view. The program uses extensive menus making it easy to use. Individual animal event data are entered, including animal identification and date. Data are entered into predefined events but only when the sequence and interval between events agrees with set biological possibilities. For example, the program will not accept a positive pregnancy diagnosis until a set number of days after a breeding event has been entered. Animal event data are stored as a cow record with two parts. One part is fixed and consists of animal identification and status data. The second part is variable and consists of an array of events sorted by lactation.

Farm data are separate from cow data and are designed to monitor the quality and quantity of feed, semen and milk and to record farm specific parameters such as voluntary waiting period and selection criteria for reproductive examination.

Most of the data to be entered have been defined in dictionaries so the database is uniform across farms and can therefore be combined for comparison or population studies.

Outputs consist of three types of reports. Management aid reports, such as lists of animals due to calve, due in heat or selected for examination, are similar to reports provided by most dairy management software. Performance monitoring reports, including periodic, evaluation, conception, conception rate, tank sample summary and heifer growth chart reports, are designed to help farmers and veterinarians detect problems and monitor various aspects of a farm. Problem analysis reports allow one to query the cow database and are designed to be used in conjunction with performance monitoring reports to provide additional information. Reports can be presented as a scatter plot, cross tabulation, histogram, bar graph, raw data list or time plot.

2.2.2 Data Collection Systems Evaluated

The project looked at two approaches to data collection. One approach studied was a herd level system with herd level data collected from the farm (HERD) and the second approach involved collecting animal and herd level data directly from various sources (ANIMAL). Data were forwarded to a central location for each system and stored in the system central data base.

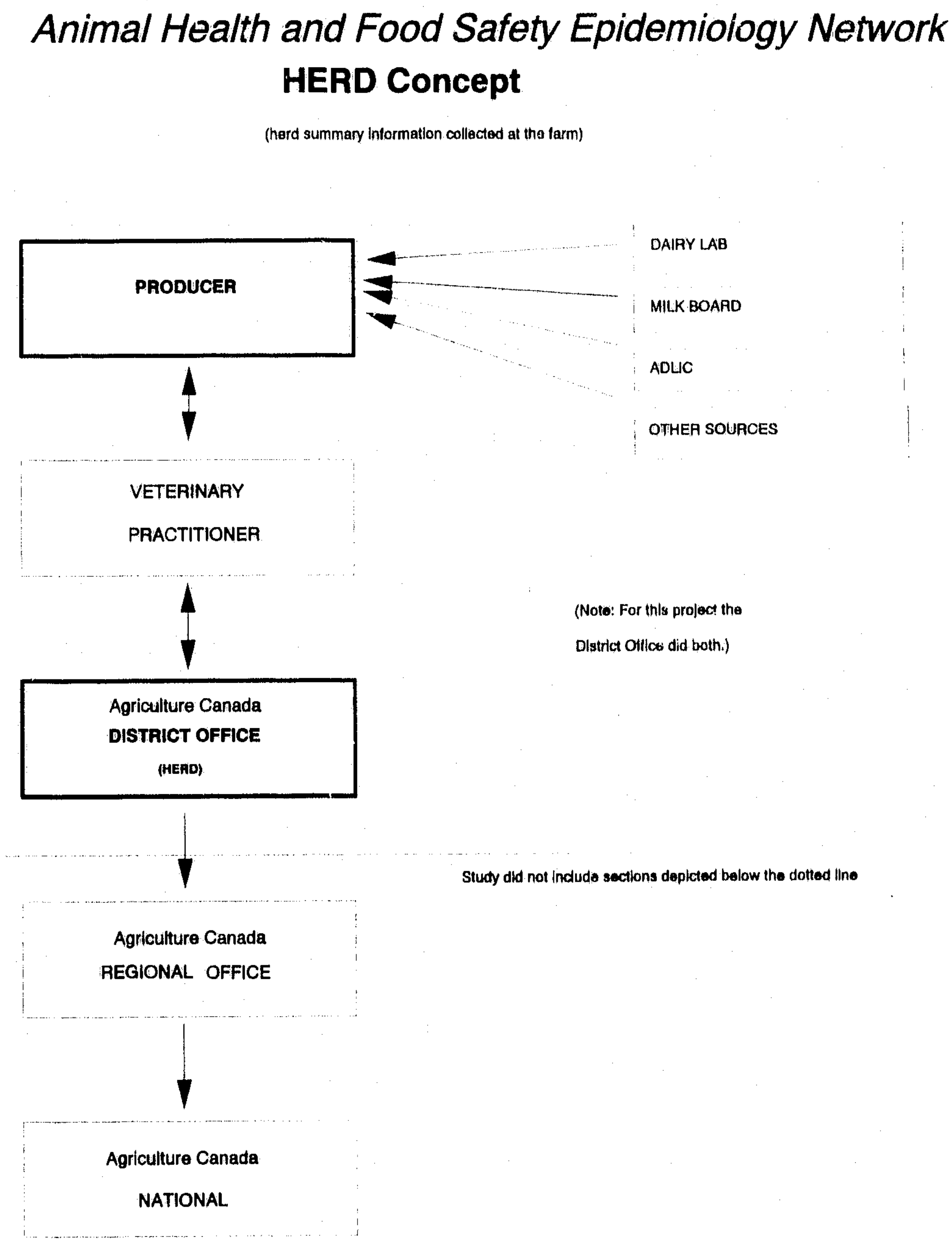
2.2.2.1 HERD Approach

This approach was based on the collection of *exclusively herd level data solely* *from the farm* (Fig. 1). Data collected were from different sources but had to be available for collection at the farm and had to be herd level data. Data collected included monthly totals of on-farm recorded daily animal events. Data from third party reports, such as bulk-tank somatic cell counts, standard plate counts and results of disc assay tests for the detection of bacterial inhibitors, from the Provincial Milk Quality Laboratory reports, were collected as well as milk volume shipped reported to the farm by the Milk Marketing Board.

For this study, data collected were limited to those data available on any farm shipping milk for human consumption. Additional herd level data were available on some farms but were not considered if not available on all farms. An example of such additional data were herd summary reports to the farm from ADLIC, the DHI organization in the region.

Monthly herd level data collected on the farm were recorded on a form and forwarded to HERD located at the District Office of Agriculture Canada, Food Production and Inspection Branch, Animal Health in Prince Edward Island (District Office) where data were entered, stored and analyzed. Periodic reports were produced comparing participating herd information to others in the study. Such comparative reports could be returned via private practitioner to the farm. Summary reports could be produced and forwarded to Agriculture Canada Regional Office and ultimately to the National Office but for the purposes of this study no reports from this system were distributed to other Agriculture Canada offices.

Figure 1. HERD concept of integrating and collating herd level data collected at the farm.



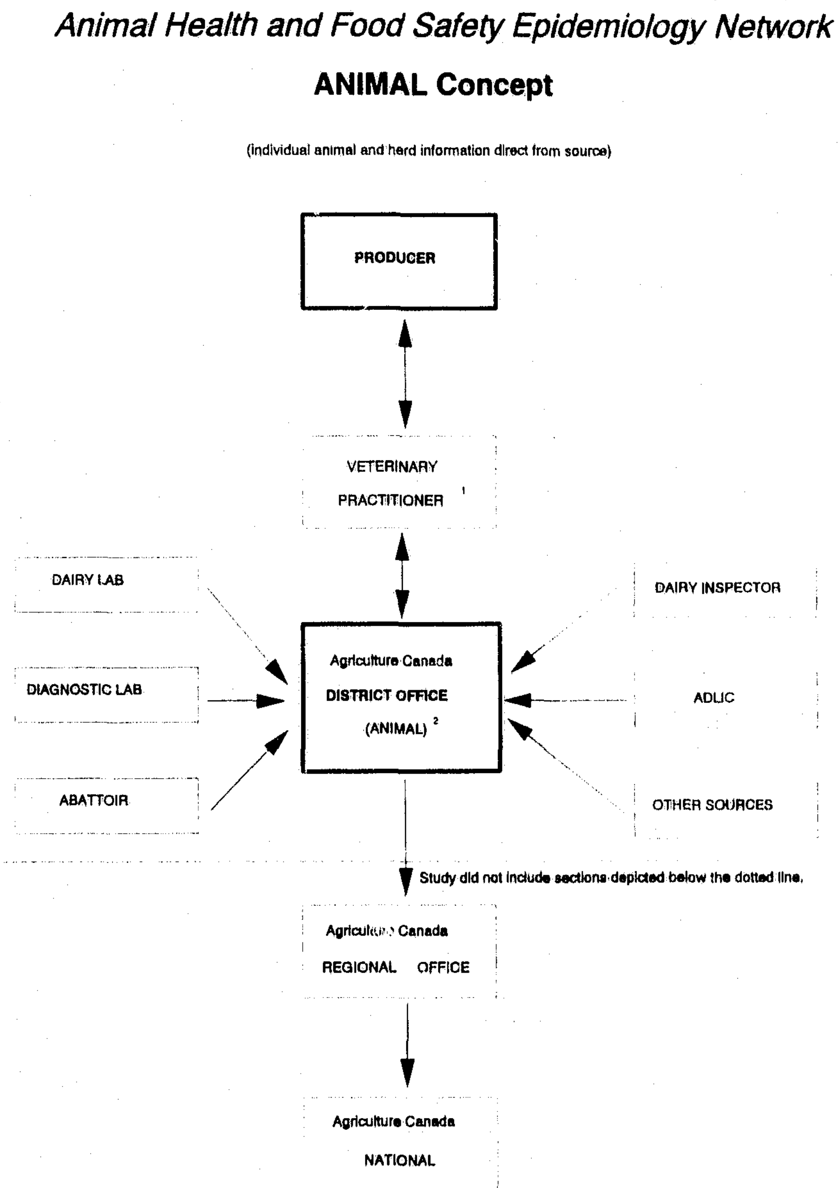
2.2.2.2 ANIMAL Approach

The second approach investigated involved the collection of *individual and herd level data collected directly from various sources* (Fig. 2). Participating farmers utilized DairyCHAMP. The District Office mimicked a private veterinary practice using this health management software program or played the role of a District Office operating a sophisticated health management program as a bureau for local practitioners. Data recorded by the health management computer program were forwarded to the ANIMAL central database where data were stored and collated with data collected directly from other sources including ADLIC and the Provincial Milk Quality Laboratory. The ANIMAL central database was APHIN located at the Atlantic Veterinary College. APHIN played the role of an ANIMAL central database located at the District Office of Agriculture Canada. Data were analyzed and comparative reports returned via the veterinary practitioner to participating farmers. There was the capability to produce summary reports and forward these to Agriculture Canada Regional Office and National Office but this was not part of this study.

2.2.3 Participants

The population of interest for this project was all dairy producers in P.E.I. enrolled in ADLIC but not currently using DairyCHAMP. Of the 516 producers shipping milk in the province, 235 were enrolled in ADLIC, and of these, 30 were using DairyCHAMP at the time the study was started. This project was a descriptive

Figure 2. ANIMAL concept of integrating and collating individual and herd level data collected from various sources.



1. Roll of veterinary practitioner was filled by the District Office for this project.
2. For this study ANIMAL Central was located at the Atlantic Veterinary College but could be located at the District Office

study being done with limited resources. These resource limitations were the primary determinants for the number of herds included in the study and dictated a maximum of 12 participants. A list of the 205 eligible producers was compiled from ADLIC and APHIN records. A random selection of 32 producers was made from this list and contacted sequentially until 12 agreed to participate. Initial contact was made by phone to advise a producer that his farm was selected at random to participate in a special project and to give a very brief outline of the project. A package of more detailed printed material was then sent by mail before the farm was visited and the producer asked to participate. A total of 18 farmers were contacted in order to attain the 12 required for the study.

The veterinary practitioners who normally worked with a participating farm were contacted and their cooperation solicited. Because of the geographic distribution of the 12 farms, five of the six food animal practices in the province were involved.

The study was limited to the milking herd on each farm. Incentive for participation was information feedback, including confidential performance assessments of a producer's farm in comparison with others using APHIN.

2.2.4 Data collection

Each farmer was provided with a form (Appendix A) designed to record the animal health and productivity events such as calving, heats, breeding, diseases and treatments, dry off dates, abortions, culling, sales, registering calves and name changes. They were asked to record events daily. On the same form they were asked to transcribe, from Milk Quality Laboratory and Milk Marketing Board reports, bulk-tank data including somatic cell count, standard plate count, milk volume shipped and percent butter fat.

An effort was made to personally visit each farm on a monthly basis to collect the data sheets and validate data by comparing the event records to other information sources such as breeding charts. If a personal visit was not possible, farmers were asked to mail the data sheet to the District Office. Data were collected for two months before the actual study period, allowing participants to become familiar with procedures, and continued for the twelve months of the study.

To simulate herd level data collection, individual animal event data were summarized manually and the monthly summary data for each event of interest were recorded on the Monthly Herd Level data recording form (Appendix A).

2.2.5 Data Processing

2.2.5.1 HERD Approach

The dBase application, ODMAP, was extensively modified to capture only herd level data, to capture additional food safety data, and to make the program reflect the characteristics of the P.E.I. dairy industry. The individual animal reproduction information database and any fields in the monthly herd information database calculated from individual animal data, were removed. All programs used for manipulation of individual animal data were removed. The database used to capture DHI herd summary data, programs used to manipulate these data, and any fields in the monthly herd information database that stored these data, were removed. Fields were added to the monthly herd information database to record number of cows milking, cows dry, cows calved, heifers calved, calves born, cows bred, cull cows tagged, cows added, milk shipped, and average butter fat tests. Analysis and reporting programs were modified to manipulate these data.

This modified program retained much of the herd analysis and reporting dBase programming provided by the Ontario researcher but the modifications were such that the original concept and intent of ODMAP were lost. The program used in this study utilized only herd level data that were collected exclusively at the farm.

The modified program (HERD) was used to capture and analyze herd level food safety and quality, production, reproductive performance, and disease data. These monthly herd level data, from the Farm Data Collection Sheet, were entered manually at the District Office.

Reports produced for the farmer and practitioner included summary reports of data entered and some calculated herd monitoring parameters (Appendix B). This information could also be compared to other farms in the system and presented in graphical format. District summary reports could be produced for transfer to the Regional Office but were not developed for this project.

2.2.5.2 ANIMAL Approach

DairyCHAMP was used to capture, store, analyze, manipulate and present individual animal reproduction and disease data collected at the farm. These activities were done by the District Office but mimicked the activity of a private veterinary practice or a producer using his own computer to run DairyCHAMP. Data collected on the Daily Event Record Sheet were entered manually each month at the District Office. DairyCHAMP was used to prepare monthly reports for distribution to the farmer (Appendix C). Each month the DairyCHAMP computer files were sent, on computer diskette, to the veterinary practitioner who normally worked with the herd. All food animal practices in the province were already using DairyCHAMP with other clients, so the veterinary practitioners could do additional analysis and produce any additional reports required for their use. These data were also transferred to the ANIMAL central database on computer diskette (mimicking a private practitioner forwarding herd summary data to the district office) where they were integrated with data concerning food safety, milk quality and production already collected from the P.E.I. Milk Quality Laboratory and ADLIC.

The ANIMAL central database was used to manipulate, analyze and generate periodic graphic reports for use by the producer and their veterinary practitioner. Graphs included herd monitoring parameters and comparisons to other farms in the system. Any of 12 graphs could be requested from the researcher (Appendix D). Veterinary practitioners could alsc produce these graphs for their client.

Summary reports could be developed for Agriculture Canada Regional Office but were not developed for this project.

2.2.6 Time Commitments

Time committed by the researcher, to the various elements of the project, were tracked to help estimate the resources required to implement a similar program on a larger geographic scale. Elements tracked included:

i) start-up time for DairyCHAMP consisting of collection and entry of individual animal biographical data (it is recognised that a learning curve associated with any system will affect the start-up time but no attempt was made to isolate this factor from the total start-up time),

ii) time to collect the Animal Event Record Sheet from the farm (when this was done by personal visit, the time recorded included any validation done by checking other records at the farm),

iii) time to count recorded daily events and transpose these monthly herd level event data and bulk-tank data to the Herd Level Data Recording form,

iv) time to enter these data into HERD,

v) time to enter individual animal event data into DairyCHAMP, and

vi) time to generate and produce reports from both systems.

An estimate of the time required to extract and analyze data required to answer specific investigative type questions was obtained by trying to answer the following sample questions submitted by an official with Agriculture Canada:

a) At any given time, what proportion of dairy herds have at least one cow on antimicrobial therapy, such that their milk should not be included in the tank?

b) At any given time, what proportion of dairy cows are on antimicrobial therapy, such that their milk should not be included in the tank?

c) What is the probability of a consumer purchasing a 2L carton of milk that is contaminated with an antimicrobial agent?

2.2.7 Validation of Data

Validation of data was done at several levels. Daily event data were validated when picked up at the farm by comparing artificial insemination (AI) charts, ADLIC work sheets, and other records. Extensive validation was done by DairyCHAMP on data entry. DairyCHAMP either refused entry or questioned data that did not fit predefined lists, ranges or sequences of events. Data from the ANIMAL central database were used to validate the estimates of herd level parameters from HERD. This was accomplished by calculating selected herd level parameters using data from HERD and comparing these to similar parameters calculated from ANIMAL. Parameters were selected to represent three types of comparisons: bulk-tank somatic cell counts were herd level data entered and stored in both systems; average individual cow milk production were individual animal data in the ANIMAL central database, summarized by ANIMAL, compared to herd level data collected and stored in HERD; the variable "days open" was calculated and summarized from individual animal data in the ANIMAL central database, compared to a herd level parameter estimated from herd level data in HERD.

2.3 Results

A total of 18 producers were contacted before 12 agreed to participate. The 6 farms that refused to participate when originally contacted were milking from 20 to 37 cows with a mean of 27 and were located throughout the province. Only 2 of the 6 farms had herd health visits by a private veterinary practitioner on a regular monthly schedule. Producers cited two main reasons for not participating. Two farmers indicated they were thinking of retiring and were uncertain if they would be in business for the duration of the project. Others were reluctant to change their existing farm event recording system and were concerned that keeping duplicate records would require too much time.

The 12 participants in the study were located throughout the province. Their herd size ranged from milking 12 to 65 cows with a mean of 27. A private veterinary practitioner made regular monthly herd health visits to 9 of the 12 farms. One producer was removed from the project after six months of failing to provide appropriate records. One farm switched from shipping milk to shipping cream soon after the beginning of the study, thereby eliminating bulk-tank data for this farm. Table I contains a summary of the herd inventory and bulk-tank food safety parameter data for participants and the six that declined.

2.3.1 Data Collection

Most farms were visited monthly to collect and validate data. The actual

Table I. Herd size and bulk tank milk safety and quality information for the period immediately prior to the project. A total of 18 farms contacted until 12 agreed to participate.

	Participants			Non-Participants		
	$\bar{x}$	minimum	maximum	$\bar{x}$	minimum	maximum
herd size[a]	27	12	65	27	20	37
btscc[b]	227	51	687	179	59	453
spc[c]	30	30	32	31	30	66

a Number of cows milking.

b Bulk tank somatic cell count (1,000 cells/ml).

c Standard plate count (1,000 cells/ml)

number of trips made to each farm is included in Table II. Farm #2 purchased their own copy of DairyCHAMP six months into the project and did their own data entry for the las' six months of the project. A copy of this farm's DairyCHAMP data was provided to the District Office on computer diskette. Regular farm visits were not made to this farm during the last half of the project. If circumstances prevented or delayed a visit to a farm, some farms would mail the data sheet to the District Office, with the result that some farms have fewer than 12 visits.

2.3.2 Data Processing

Data were entered manually into DairyCHAMP and HERD on a monthly basis at the District Office. Reports generated using DairyCHAMP, including action lists for herd managers and a breeding work list, were mailed to the farmer each month. Animal history and animal identification lists were also sent periodically for validation by the farmer.

2.3.3 Time Commitments

Table II contains a summary of the time commitments tracked during the project. These include: time to recruit participating farmers, time to start a farm on DairyCHAMP and allow participants to become familiar with the procedures by participating for two month before the study period, various components of time committed during the 12 month project period.

The reporting times presented in Table II represent time to generate and mail

Table II. Time committed to various aspects of a 12 month Productivity, Health and Food Safety Epidemiology Network pilot project.

					Data Collection			Data Entry			Reports	Data Collection & Entry	
					ANIMAL	Daily	Monthly	DairyCHAMP		HERD[j]	Gen &		
	Herd Size[a]	Trips[b]	Travel[c] (min/t)	Recruit[d] (min)	Start[e] (min)	Events[f] (min/t)	Summ[g] (min/m)	Start[h] (min)	Event[i] (min/m)	(min/m)	mail[k] (min/m)	ANIMAL[l] (min/m)	HERD[m] (min/m)
Farm 1	13	10	42	20	105	11	16	120	33	8	14	44	35
Farm 2	25	6[n]	33	20	50	15	10	130	23	2	10	38	27
Farm 3	25	12	43	20	200	14	20	120	25	5	20	39	39
Farm 4	34	12	27	40	170	19	12	245	28	5	21	47	36
Farm 5	29	11	47	20	85	13	15	205	27	6	18	40	34
Farm 6	29	12	29	15	115	27	18	200	29	6	13	56	51
Farm 7	24	12	35	20	125	13	7	315	23	5	13	36	25
Farm 8	29	13	44	20	90	18	7	215	26	5	17	44	30
Farm 9	35	8[o]	105	20	250	9	16	490	21	6	9	30	27
Farm 10	15	10	35	40	35	11	10	40	25	4	13	36	25
Farm 11	62	7[p]	21	20	90	29	10	110	62	5	25	91	44
Farm 12	22	12	37	20	80	18	11	145	34	8	12	52	37
Mean	28	10	42	21	107	15	13	180	27	5	15	46	34

Footnotes on next page.

Table II. continued

a. Average number of cows milking each month.

b. Number of trips made to the farm.

c. Average time (minutes/trip) travelling to and from the farm.

d. Time (minutes) on the farm reviewing the project and asking the farmer to participate.

e. Total time (minutes) on the farm collecting biographic and historic data for all the cows in the herd. The time would depend on the number of cows and the amount of historical data collected.

f. Average time (minutes/trip) spent on the farm collecting and validating daily event data sheets.

g. Average time (minutes/month) totalling daily events and recording the totals on the monthly Farm Data Collection Sheet.

h. Total time (minutes) entering biographic and historic data into DairyChamp.

i. Average time (minutes/month) entering daily event data from the Data Recording Sheet into DairyChamp.

j. Average time (minutes/month) entering data from the Farm Data Collection Sheet into HERD.

k. Average time (minutes/month) generating and preparing for mailing, predefined reports from DairyChamp.

l. Total time (minutes/month) collecting and entering daily event data into DairyCHAMP for the ANIMAL system.

m. Total time (minutes/month) collecting daily event data, summarizing data and entering the monthly summary data into the HERD system.

n. This farm purchased their own copy of DairyChamp and started their own data entry half way through the study period.

o. This farm often sent the Data Recording Sheets in by mail requiring fewer trips to the farm.

p. This farm was dropped from the study after 6 months.

the monthly DairyCHAMP reports only. At the end of the project, twelve-month herd summary reports, from both DairyCHAMP and HERD, were generated for each farm. These reports were produced using an IBM compatible 386 SX microcomputer and a printer that printed 160 characters per second. The DairyCHAMP twelve-month herd summary and analysis report for each farm was 4 pages in length and required an average of 10 minutes/farm to generate, print and prepare for mailing. The HERD twelve-month herd summary and analysis report was 2 pages long and required 5 minutes/farm to generate, print and prepare for mailing.

The sample questions submitted by Agriculture Canada concerning the probability of antimicrobial agents in bulk-tank milk were answered using HERD level summary data from the 12 farms. Determining the appropriate data, extracting that data and analyzing this data required approximately two hours. This did not include any time for report preparation required to properly present these results. Details of the procedures used to answer the first two questions have been included (Appendix E). The question concerning the probability of a consumer purchasing retail milk contaminated with antimicrobial residue, could not be answered by the information in the systems being used for this project.

2.3.4 Validation of Data

Herd monitoring parameters were calculated using data in HERD and compared to similar parameters derived from ANIMAL data. Some herd level data present in both systems should be identical. The bulk-tank data were sent on computer diskette directly from the Milk Quality Laboratory to the ANIMAL central database. The same data were transposed from Milk Quality Laboratory reports received on the farm onto data collection sheets and entered into HERD. Table III contains a summary of bulk-tank somatic cell count data from each system.

Some herd level parameters that were entered directly into HERD were summarized from individual animal data by the ANIMAL central database. An example was the average milk production per day per cow contained in Table IV.

The ANIMAL central database received other individual animal data that were summarized and presented as herd level parameters. Without the individual animal data, HERD could only estimate such parameters. An example, presented in Table V, was average days open calculated from data in ANIMAL and estimated from data in HERD.

2.4 Discussion

The sample size of 12 farms was small if hypothesis testing had been the purpose of the project but was adequate for the evaluation of the two systems examined. Most participating herds were smaller than the provincial average of 40 cows per herd. Producers with small herds might perceive less benefit from a computerized record system and thereby have less incentive to comply with the recording of all data requested. In this project however, the largest participating herd was the one that was ultimately excluded because of non-compliance.

Table III. Comparison of bulk tank somatic cell count data stored in ANIMAL and in HERD.

Mean Monthly Bulk Tank Somatic Cell Count (1000's cells/ml)

farm	ANIMAL[a] BTSCC	HERD[b] BTSCC	diff[c]	corr[d]
1	446.33	449.70	0	1.00
2	64.40	70.45	0	1.00
3	530.90	523.50	0	1.00
4	146.60	143.18	0	1.00
5	78.11	84.40	0	1.00
6	299.20	290.25	0	1.00
7	110.56	98.00	0	1.00
8	229.30	229.30	0	1.00
9	157.56	154.70	0	1.00
10[e]	104.50	104.50	0	1.00
11[f]	109.42	97.50	0	1.00
12	255.40	244.55	0	1.00

a Mean monthly bulk tank SCC summarized from data stored in ANIMAL. If present the data should be identical in each system. The different means are because of missing data in ANIMAL and HERD.

b Mean monthly bulk tank SCC calculated with data stored in HERD. Different means result from missing data in HERD and ANIMAL.

c Mean of the difference between the value stored in ANIMAL and the value stored in HERD for each month that had a value in both.

d Correlation coefficients between the data in ANIMAL and the data in HERD.

e Data for the first month only.

f Data for the first six months only.

Table IV. Comparison by farm of average milk (kg)/cow/day as summarized from data stored in ANIMAL and calculated from data stored in HERD.

		Mean Milk(kg)/Cow/Day			
farm	ANIMAL[a]	HERD[b]	diff[c]	abs_d[d]	corr[e]
1	21.84	19.06	3.08	3.08	0.692
2	28.23	24.49	3.40	3.62	0.675
3	18.93	18.71	0.22	1.13	0.675
4	25.93	22.48	3.73	3.88	0.400
5	25.92	23.13	2.50	2.60	0.887
6	23.67	22.01	2.13	2.15	0.539
7	29.11	22.43	6.78	6.78	0.681
8	25.50	22.67	3.29	3.57	0.416
9	23.89	18.81	5.34	5.34	0.657
10[f]	14.74				
11[g]	29.51				
12	24.41	25.99	-1.69	2.70	0.530
overall mean	24.31	21.98	2.88	3.48	0.615

a Mean of the monthly milk produced per cow on test day each month and reported by ADLIC to ANIMAL.

b Mean of the monthly total milk shipped/cows milking the last day of the month/days in the month, calculated from data stored in HERD.

c Mean of the difference between the monthly value calculated from ANIMAL minus that calculated from HERD.

d Mean of the absolute difference between the monthly value calculated from ANIMAL minus that calculated from HERD.

e Correlation coefficient between the monthly value from ANIMAL and that calculated from HERD.

f Switched from shipping milk to shipping cream during the first month of the study therefore there are no milk shipped data in HERD. Farm continued in ADLIC therefore data in ANIMAL.

g Six months of data were collected from HERD but milk shipped data were not provided by the farmer. ADLIC data went directly to ANIMAL.

Table V. Comparison by farm of mean days to conception calculated from data in ANIMAL and estimated from data in HERD.

Mean Days to Conception

farm	ANIMAL[a]	HERD[b]	diff[c]	calved[d]	cows[e]
1	102	243	141	10	14
2	112	87	-25	29	29
3	158	415	257	14	27
4	110	337	227	22	37
5	89	260	171	21	31
6	108	306	198	19	31
7	127	156	29	22	26
8	128	236	108	23	33
9	136	160	24	32	39
10	115	251	136	11	16
11[f]	121	322	201	21	70
12	114	273	159	16	24
overall mean	118	254	136	20	31

a Days to conception calculated by ANIMAL (average number of days from calving to conception for cows which are confirmed pregnant during the month).

b Estimated days to conception using HERD data.
[{1 / calving rate (calves/cow/day)} - 280 days]

c Difference between the calving interval calculated with ANIMAL data and estimated with HERD data.

d Total number of cows that calved during the study year as reported by HERD.

e Average of the number milking the last day of the month minus the number of heifers that calved during the month.

f Based on six months data.

When farmers who agreed to participate were compared with those who declined, it was noted that farmers utilizing a regular herd health program through their veterinarian were more willing to participate.

A follow up three months after the project found five of the twelve farmers still utilizing DairyCHAMP through their veterinary practitioner. Those no longer using DairyCHAMP included the one small farm that had switched from shipping milk to separating cream, three farms that did not utilize regular herd health visits during the project, and three farms using the services of a veterinary practice that had DairyCHAMP but had no practitioner actively using and supporting a computerized health management program.

2.4.1 Data Collection

Most farmers had little trouble adapting to the recording of some daily events on the form provided. Since many producers were reluctant to stop existing record systems, this represented a duplication of effort for the recording of some daily events and therefore met with varying levels of compliance. Getting compliance for the transcribing of data from other reports onto the data collection sheet was difficult in most cases. Farmers readily recorded information they felt would benefit them but were reluctant to spend the time recording or transposing information that they could not relate to their needs. This response would indicate a simple herd level information system, based on only data from the farm, would have substantial difficulties collecting some of the data desired unless data collection staff visited the farm on a regular basis to record or transpose some information.

Data collection did not truly mimic a herd level system. We were reluctant to ask the producers to keep two additional sets of records for this project, therefore the herd level summary of daily event data was done at the District Office to mimic the activity of a farmer asked to provide the herd level data. If farmers were asked to submit only this herd level data collection sheet, without daily individual animal data, validation of monthly herd level data would have been impossible.

Transcribing data from one form to another and manual entry of that data is a potential source of error. With any system it would be desirable, if possible, to transfer data electronically if they already exist in a computerized format.

2.4.2 Time Commitments

The average 287 minutes per farm required to gather biographical data, to gather historical health and reproductive data, and then enter those data in DairyCHAMP, represented a one-time cost. Such costs may vary with the program, but would be part of starting any individual animal computerized health management recording program.

Data collection time is dependent on the method of collection. Our data collection time included time to collect the data sheets from the farm, do some validation and attempt to gather any missing data. A substantial amount of this time was spent trying to collect bulk-tank data that the farmer had not transcribed onto the data collection sheet. One might expect the personal farm visit used for this project to require more time than would be expected for a strictly mail-in method but, as previously indicated, completeness of data might then be a problem and validation of data would be impossible. With the necessity for continual follow up to collect bulk-tank data from the farm, time commitments to collect farm source data for either system might indeed be similar.

The HERD Summary time (average 10 minutes/month/farm) was time and activity that the farmer might be asked to do with a HERD type system. With an individual animal based program, this summarization is done by the computer. The data entry time for HERD (average 5 minutes/month/farm) was for the entry of numbers from the monthly Farm Data Collection Sheet, with no validation of the data upon entry.

Validation was an integral part of DairyCHAMP data entry. A significant portion of the average 27 minutes per month per herd for this data entry was time required to sort out or clarify data that the program would not accept or would question.

Reporting time would vary considerably depending on the amount and type of reports being generated and the speed of the hardware components in the system. DairyCHAMP and the ANIMAL central database collected and stored much more data and, therefore, could perform more analyses and report much more information. The time required to generate year end reports from HERD was only half that required for DairyCHAMP. Part of this difference was related to the different lengths of the reports and part was because HERD had the capability to print reports for all farms in one batch. This multi-farm batch capability was not available with DairyCHAMP. Although more time was required to print reports one farm at a time, DairyChamp reports contained much more information to facilitate decision making by producers and their veterinarians. Considerable time could have been spent interpreting and discussing this information. It was our decision that this activity should be left to the farmer and his veterinary practitioner.

The hypothetical questions posed by Agriculture Canada concerning the probability of antimicrobial residue in the bulk-tank milk could be answered with high confidence by a regional or national information system that had summarized herd level data from a large population of dairy herds. The information required to answer the third question was not collected by the systems being studied. The probability of antimicrobial residue in retail milk was dependant on the probability of antimicrobial residue in the bulk-tank, the sensitivity of the tests used to detect antimicrobial residue in the truck sample (hence, the probability of contaminated milk being detected and removed prior to entering the processing plant), and the proportion of milk that was processed for the fresh retail market compared to the amount processed for other dairy products. Some additional food safety monitoring was done that looked at the sensitivity of tests and the probability of antimicrobial residue being undetected in truck samples. Those results are presented in Chapter 3. A national animal production, health and food safety epidemiology network would facilitate research required to help answer these kind of questions.

2.4.3 Validation of HERD Data

Three types of parameters were examined. The bulk-tank data were the same herd level data going into both systems and should be identical in both systems. Any discrepancies in the HERD data would be the result of transcription error or data entry error. When present in both systems, the bulk-tank somatic cell count data were identical. If the farmer failed to provide this data, it was missing in HERD. Any missing data in ANIMAL would be a result of that data not coming from the laboratory.

The production parameter, milk per cow per day, represented a parameter calculated with herd level data stored in HERD compared to individual animal data in ANIMAL that were summarized by ANIMAL. The HERD parameter had a mean of 2.88 kg of milk/cow/day less than the ANIMAL parameter. ANIMAL used the mean of the monthly average milk production per cow on test day each month as reported by ADLIC and as such was a measure of production for those cows tested. HERD used the mean of the monthly milk shipped, per number of cows milking the last day of the month, per number of days in the month. This parameter reflected production but was a measure of milk shipped rather than milk produced. As observed, the amount of milk shipped was expected to be less than the amount produced considering some was usually fed to calves and some may have been used for domestic consumption. Some milk may also have been withheld from the bulk-tank owing to antimicrobial therapy and related drug withdrawal time.

The reproductive parameter, days to conception, was calculated from individual animal data in the ANIMAL central database as the average number of days from calving to conception for cows which were confirmed pregnant during the month. Without the individual animal data, HERD could only try to estimate such parameters. For this estimation we calculated the calving rate then determined the calving interval for the average cow and subtracted 280 days for gestation. The results from the two systems were within 30 days for only 3 of the twelve farms. The difference between ANIMAL and HERD for the other nine farms ranged from 107 days to 257 days. If the cow population on the farms were stable, this herd level parameter estimate might have served as a useful monitoring tool but when the cow population was dynamic, with a lot of culling and replacement, this estimated parameter had little value.

2.4.4 Conclusions

Both data collection systems used for this project appeared to be feasible bases for a national animal productivity, health and food safety epidemiology network. HERD, operated at the District Office, required a minimal infrastructure and therefore would be simpler to implement than an ANIMAL type system. Farmers could be asked to provide the District Office with only herd level data, requiring relatively little data entry time. The system was not reliant on DHI participation and, therefore, could be implemented on all farms that ship milk. Reports that compare a farm's performance to others could be provided to all producers contributing to the system. Health and food safety summary data would be available for a national information network.

Although a minimal infrastructure is required, this system involves direct communication with many individual producers in the district. This may be an advantage but would require a considerable amount of time. Communication between the District Office and the private veterinary practice is desirable but not an essential part of this approach. It would be advantageous to have the veterinary practitioner provide the herd summary data for any farms utilizing a health management software program through the veterinary practice. Other data would still be transposed from reports at the farm and forwarded to the District Office. For farmers who submitted all the data directly to the District Office, copies of reports could be sent to the veterinarian of their choice to assist with interpretation of the information. This would provide some ongoing communication between the District Office and the veterinarian.

However, a system based on direct collection of herd level data directly from the farm has a number of disadvantages. Producers need and keep individual animal records, as well as herd level records, to make the kind of management decisions required. The summarization of these individual animal data required for HERD would be an extra activity for the farmer. In our experience the expected producer compliance level for transposing information from other reports onto the herd level data collection sheet would be very low. With the limited ability to validate data, plus the potential of transposition error, the reliability of the collected data would be questionable. The herd level system, because of the lack of individual animal data, contains very limited reproductive information and has limited herd analysis capabilities. With the incentive for producer participation being information feedback, the inability to critically analyze herd performance may lead to low producer compliance.

It must be stressed that the disadvantages of HERD, a herd level system, collecting only herd level data, and collecting all data from the farm, do not apply to ODMAP as it is being used in Ontario. The concept of ODMAP is in fact very similar to ANIMAL in that it collects individual animal data from the farm and collects other data directly from alternative sources (eg. DHI organization). The differences between ODMAP and ANIMAL are with the level of information stored and the methods used to collect, transfer and manipulate data.

As stated, the ANIMAL approach, with the District Office being the local ANIMAL central database, is also a feasible basis for a national information network. The health and food safety summary data required for a national information network would be available at the District Office for transfer to the regional and national level.

Some advantages of this system include the ability to transfer data, on tape or computer diskette, from veterinary practices, DHI programs, and milk quality laboratories and, thereby, eliminate data input costs to the District Office. Sophisticated health management programs do a lot of data validation on entry, making the information being transferred to the District Office more reliable. Other data, because they are being transferred on computer tape or diskette directly from source (i.e. laboratory, DHI, etc.), are also more reliable.

Individual animal data stored at the District Office would enable more extensive analysis at the District level. More questions of local concern as well as regional and national concern could be addressed with individual animal data. The advances in computer data storage and the dramatic reductions in costs, make the storage of individual animal data at the District Office quite feasible.

A system based on individual animal data permits better herd analyses and generation of more useful information to better facilitate decision making at the farm level. This in turn increases the incentive to participate for both producers and veterinarians.

Using this system the District Office is in direct contact with only a few agencies and veterinary practices, a much smaller number of direct contacts than required for HERD. However, this direct communication with veterinarians is at the expense of the direct communication with individual producers required for HERD.

The major disadvantage of an ANIMAL approach is the more complex infrastructure required and the need for the cooperation of several individuals and agencies in order to have the required data transferred to the District Office. A second disadvantage is that currently the system relies on DHI records for production information making the system unavailable to those not enrolled in a DHI program. This system could, however, be modified to collect herd level production data from another source. Standardization or limitations on the number of different health management software programs used by participating veterinary practices would be necessary to ensure the same information could be collected from all participants and to minimize the number of transfer protocols required. Participation would be restricted to farmers utilizing a supported health management software program. This restriction could be minimized if the District Office was established as a bureau that offered the services of a sophisticated health management software package to local veterinary practices and producers. This would require considerably more resources for data entry and routine report distribution but may be a service that could be marketed.

The ANIMAL concept has considerable advantages over the HERD concept. Although ANIMAL does require the establishment of an extended infrastructure, the number of individual contacts is much less than the number of individual producer contacts required of the simpler HERD. The resources required at the District Office have not been fully assessed although they would be used differently and may not be much different in total for either system HERD would require resources to deal directly with many individual producers while ANIMAL would use those resources to deal with a few veterinary practices, the DHI association and the local milk quality laboratory.

The base of a national animal productivity, health and food safety epidemiology network could be piloted by implementing either of these systems in an Agriculture Canada District Office.

3. ADDITIONAL FOOD SAFETY MONITORING

3.1 Introduction

The farm is the first critical control point along the food chain. Improving our farm level food quality and safety monitoring, therefore, is crucial. One way to improve monitoring is to increase the frequency of existing procedures or to develop different methods. The integration of such improved monitors into a comprehensive regional or national food animal productivity, health and food safety monitoring system, along with the implementation of an animal identification and trace back system, could be used to help validate or certify sound production practices and ensure consumer confidence.

One objective of this study was to develop and test the feasibility of establishing basic farm level monitors of milk and meat safety. The specific objectives of this chapter are: 1) to describe some additional monitoring of food safety that was done, 2) to discuss the value of this additional monitoring.

3.2 Materials and Methods

Additional bulk-tank sampling for standard plate testing and antimicrobial residue testing was done. An attempt was made to identify cull cows sold from participating herds and trace them to slaughter.

3.2.1 Milk Bacteriology

The effect of storing milk samples in a commercial freezer, on milk bacterial cell counts, was investigated. A total of 180 bulk-tank samples that had been tested using the Standard Plate Count (28), were frozen at -20°C for varying lengths of time from 2 weeks to 4 months. These samples were then thawed overnight at 4°C and retested using the same Standard Plate Count procedure. The repeatability of the Standard Plate Count (SPC) was also examined. The SPC was done in triplicate using 110 of the fresh samples prior to freezing those samples.

Within the PEI dairy industry, milk is picked up from each farm by tanker truck once every 2 days from all fluid shippers and once every 3 days from industrial shippers. A sample is drawn from each bulk-tank by the truck driver immediately before loading. These samples are stored on ice and delivered daily, along with a composite truck load sample, to the Milk Quality Laboratory. Each week, for 60 consecutive weeks during this study, one bulk-tank sample per participating producer was frozen and stored at -20°C. Every fourth week the corresponding truck sample, for each of the twelve bulk-tank samples stored, was also collected, frozen and stored at -20°C. Samples were thawed and tested, using the Standard Plate Count at three dilutions, 1:100, 1:1000, and 1:10000, as Milk Quality Laboratory operations allowed (approximately once per month).

3.2.2 Antimicrobial Residue in Milk

Weekly bulk-tank samples, when thawed, were also tested for the presence of antimicrobial agents, by the Milk Quality Laboratory, using the *Bacillus stearothermophilus* disc assay (28). Bulk-tank samples for which a corresponding truck sample had been saved, were refrozen and stored until the end of the sampling period. When all samples had been collected they were tested for the presence of antimicrobial residue using the LacTek test for sulfamethazine (29) and β-lactam based antibiotics. (30).

3.2.3 Meat Safety

Participating farmers were provided with coloured Agriculture Canada Health of Animal (H of A) metal ear tags and taggers. They were encouraged to identify cull cows with this unique ear tag, prior to the cows leaving the farm. Government meat inspectors at the two federally inspected abattoirs in the region were instructed to notify the District Office with the identity of any cow presented for slaughter, bearing a coloured H of A ear tag.

3.3 Results

3.3.1 Milk Bacteriology

The effect of freezing milk samples on the results of the standard plate count was compared to the variation observed with replicate fresh samples. All standard plate counts were transformed to base 10 logarithms before analysis and all analyses were done using the statistical program STATISTIX (31). For the 110 fresh milk samples plated in triplicate, the average difference observed between any two of the three replicate plates was 0.01 $\log_{10}$cells/ml (SD=0.14) and ranged from +1.01 to -1.08 $\log_{10}$cells/ml. An analysis of variance showed the variability between the three replicate counts of one sample was not significantly different than the variability within the groups of samples ($F_{2,327}=0.67$ $p=0.52$). The average of the three replicate counts was used to calculate the difference between the fresh and frozen count for that sample. Frozen counts tended to be slight lower than fresh counts ($\bar{x}=0.13$ $\log_{10}$cells/ml, SD=0.17, minimum= -0.36, maximum= 0.75). A few samples had larger counts after freezing but the range of the differences seen between fresh and frozen counts was within the range of the differences observed between fresh sample replicate counts. The distribution of the differences observed are depicted in Appendix F.

The ability to predict the fresh sample standard plate count with a count from a sample that had been stored frozen was modeled using linear regression with the following result: $\log_{10}(\text{fresh}) = 0.241 + 0.960 \log_{10}(\text{frozen}) + 0.001$ days frozen ($R^2 = 0.94$). The number of days the sample was frozen had a significant but relatively small impact. Detailed output of these analyses are included (Appendix F).

The weekly bulk-tank samples collected from participating farms during the project did show isolated plate counts higher than normal for that farm but no sustained period of increasing bulk-tank standard plate counts were observed on the farms studied. Graphical presentations of the regular twice monthly standard plate counts and the additional weekly plate counts for the study period have been generated for each farm (Appendix F).

3.3.2 Antimicrobial Residue in Milk

All 480 additional bulk-tank samples were officially negative when screened for antimicrobial residue using the disc assay. One of the 480 samples showed some inhibition but less than the positive standard and was therefore classified negative. One sample per month was to be refrozen, but for some months they were inadvertently discarded. A total of 83 samples, representing 7 to 8 months for each of the 11 farms shipping milk, were tested using the LacTek sulfamethazine and β-lactam tests. Three of these samples, each from different farms, tested positive for sulfamethazine. Two samples from the same farm, one in November 1991 and one in January 1992, tested positive for β-lactam antibiotics. Four of five composite truck samples containing milk from one of the five contaminated bulk-tanks were negative when tested with LacTek sulfamethazine and β-lactam tests. One sample that corresponded to a sulfamethazine positive bulk-tank samples was positive for sulfamethazine.

3.3.3 Meat Safety

During the project a total of 92 cows were reported culled. Only 10 were tagged with the H of A ear tags provided to the farmers. None of the 10 tagged cows were identified by government inspectors at the federally inspected abattoirs in the region.

3.4 Discussion

3.4.1 Milk Bacteriology

Our study found freezing the milk samples tended to lower the standard plate count, but the change was within the variation observed with triplicate testing of fresh samples. Some studies have examined the effect of freezing on mastitis pathogens and observed that freezing affects the survival of some mastitis pathogens and not others (32). For the purposes of our project, the comparison of individual farm bulk-tank standard plate counts done on routine fresh samples and additional weekly frozen samples was possible considering the predictability of the plate count for a fresh sample given the results from a frozen sample..

The Provincial Dairy Lab routinely did the Standard Plate Count at 1:1000 dilution on at least one bulk-tank sample per producer per pay period (pay periods were from the 1st to the 15th and from the 16th to the end of each month). If that count was above the allowable limit, a second Standard Plate Count was done in the same pay period. The additional monitoring of milk safety performed during this project was an effort to provide more food safety information. Earlier detection of a sustained high plate count is desired. No such occurrences were observed therefore, the additional testing had no opportunity to identify such a developing problem. Isolated counts above the norm for that farm were occasionally observed as depicted in Appendix F. Bacteria in the bulk-tank milk originate from three sources: intramammary infections, external mammary surfaces, and surfaces of milking or storage equipment (33,34,35). Poor cleaning of equipment or improper premilking udder preparation could result in isolated higher counts. The increased frequency of bulk-tank testing increased the probability of detecting such occurrences.

3.4.2 Antimicrobial Residue in Milk

The Prince Edward Island Milk Quality Laboratory official test for the detection of antimicrobial residue in milk was the Difco *Bacillus stearothermophilus* disc assay procedure with a 0.01 IU/ml positive standard (36). This test effectively detects the residues of most β-lactam antibiotics but is much less effective in detecting many of the other drugs now being used by the dairy industry (37). The laboratory tested every truck load of milk. Any milk sample with a zone of inhibition greater than the positive standard was reported as positive for the presence of antimicrobial agent. If inhibition was present but less than the standard, the sample was noted but officially classed as negative. Differentiation was made among penicillin, an antibiotic other than penicillin, or a combination of inhibitors. If the truck sample was positive then the bulk-tank samples of all contributors to that truck load were tested using the same method. A few additional individual bulk-tank samples were tested periodically as extra monitoring. Our additional 480 bulk-tank samples, tested using this disk assay, did not identify any positive bulk-tank milk samples that truck sample testing had failed to identify.

The sensitivity claimed for the LacTek β-lactam test is 0.007 IU/ml and at least 10 ppb for the LacTek sulfamethazine test. Studies have confirmed this sensitivity and have demonstrated that the specificity of these LacTek tests are near 100% (38,39,40,41). The additional testing we did with the these tests demonstrated the relatively low sensitivity of the disc assay for the detection of sulfamethazine and when using a 0.01 IU positive standard for the official disc assay test, some β-lactam antibiotic residue went undetected.

Four of five truck samples that contained milk from the five LacTek positive bulk-tanks were negative when tested with the same LacTek tests. Dilution, however, should not be the answer to eliminating antimicrobial residue in milk. The use of rapid cow-side testing and bulk-tank testing should be encouraged to detect and remove contaminated milk from the system before it is diluted in the truck.

3.4.3 Meat Safety

Carcasses are being monitored for antimicrobial and other chemical residues in federally inspected abattoirs. Limited on-site testing abilities are available for the abattoir but the capability of rapid testing, on the slaughter floor, for residues and meat quality is not currently available. The ability to trace animals with residue in their muscle, from slaughter to the farm of origin, is essential if the source of contaminants is to be identified and eliminated. A national animal identification system that identifies individual animals before they leave the farm of origin would enable traceback of animals with tissue residues or disease. The very low compliance level for our voluntary identification of cows prior to culling would indicate that a compulsory identification system is required if a traceback system is to be effective.

4. FACILITIES AND SANITATION ON THE DAIRY FARM AS PREDICTORS OF MILK QUALITY AND SAFETY.

4.1 Introduction

Consumers today demand safe products of high quality. The dairy producer is, therefore, asked to produce milk free of bacteria and inflammatory or antimicrobial residue. In an effort to improve milk quality, the dairy industry and government agencies have set regulatory limits for bulk-tank somatic cell counts (BTSCC), bulk-tank bacterial counts and antimicrobial residue.

Regulatory limits on BTSCC are becoming more stringent worldwide. In January 1992, the European Community set the regulatory limit at 400,000 cells/ml. Six months later, Ontario began a 6 year step-wise program to drop the limit from 800,000 to 500,000 cells/ml. In July 1993 the United States decreased its limit to 750,000 cells/ml. In Prince Edward Island the regulatory limit is currently 750,000 cells/ml for industrial milk and 500,000 cells/ml for fluid milk.

Similar changes in regulatory limits on bulk-tank bacterial counts have occurred. In July 1992, Prince Edward Island reduced the regulatory limit for bacteria in bulk-tank milk, as measured by the standard plate test (28), from 250,000 to 200,000 cells/ml for industrial milk and from 75,000 to 50,000 cells/ml for fluid milk.

In many jurisdictions the regulatory tolerance for antimicrobial residue is at or near the detectable level of the test being used by that jurisdiction.

The farm is an early critical control point along the food chain and, as such, a desirable level to start controlling milk quality and safety. However, bulk-tank somatic cell counts and bacterial plate counts are known only after the milk has entered the processing system. Phase three of the original research proposal discussed in Chapter 1, involved development and verification of indices that measure food safety at the farm level. For example, dairy farm facilities and sanitation can be assessed prior to the milk entering the processing system. Use of such indices can contribute greatly to the safe and healthy production of food. Knowledge of relationships among these various factors could be used by regulators to adjust the limits of parameters currently being regulated or to identify farms that require a greater level of surveillance.

Monitoring the somatic cell count (SCC) and bacteriology of bulk-tank milk has been used to evaluate the status of mammary health in the herd (42). Recent studies have looked at the association between SCC, bacteriology and inhibitors (43) and at the associations of somatic cell counts with individual farm characteristics and previous SCC readings as a possible predictor of future readings (44).

The objective of this study was to determine if dairy farm facilities and sanitation, as scored by the Prince Edward Island Department of Agriculture inspectors, predict three food safety and quality parameters (somatic cell count, standard plate count and antimicrobial residue) of bulk-tank milk.

4.2 Materials and Methods

Attempts were made to develop 6 predictive models, one model to predict each of the three food safety and quality parameters using both an annual and a three month time period for each of the three parameters.

4.2.1 Data

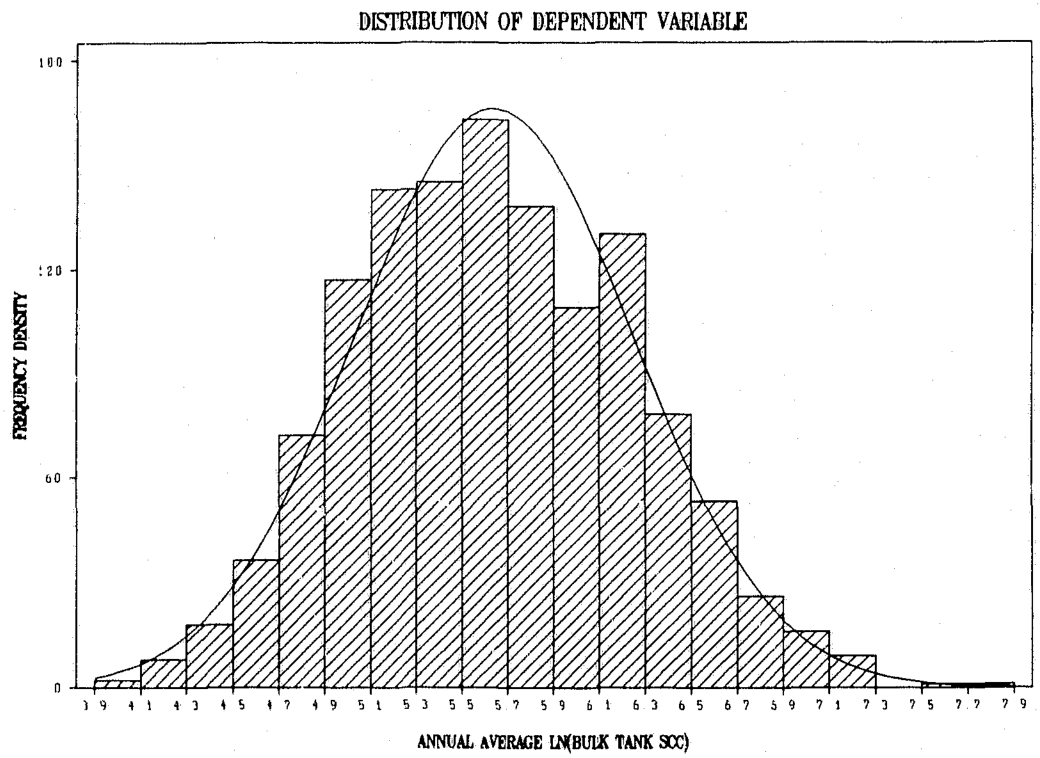
All dairy herds in Prince Edward Island were used in this study. One of 4 PEI Department of Agriculture inspectors made an annual visit to each dairy farm to inspect and score their facilities and sanitation. Facility scores for the following areas were recorded: general, milkhouse, milk storage and washing, milking area (barn or parlour). Sanitation scores were also recorded for the following: general, cattle cleanliness, milkhouse, interior and exterior cleanliness of equipment, milking area (barn or parlour). Each of these scores was derived from a total of several component scores. For example, the facility milkhouse score included a score for size, walls-good repair, ceilings-good repair, windows-good repair, floors-impervious-good drainage, drains-adequate-covered, lights and location, ventilation, openings screened, doors-self closing, proper hoseport, concrete or asphalt slab. All scores were on an ascending scale; the better the facilities and sanitation, the higher the score. All components of these scores and the scoring guidelines used by inspectors are included in Appendix G. Beginning in 1989, these dairy farm inspection scores were stored using the database program dBase (25). The data, for the 4 calendar years 1989 to 1992, were used for this investigation. Predictive models were developed using data from years 1989 to 1991 and the predictive ability of these models was tested using the 1992 data.

Provincial Dairy Laboratory data, for each producer shipping milk during the same period, had been maintained in the APHIN (23) central database. These data included bulk-tank somatic cell counts determined using a Fossomatic 215 cell counter, bulk-tank standard plate counts (28), and bulk-tank bacterial inhibitor residue determined using the DIFCO disc assay (36).

The APHIN central database was used to generate, for each producer with an inspection score, an average BTSCC for the calendar year in which the dairy farm inspection was done and an average BTSCC for a three month period including the month the dairy farm inspection was done plus the month before and the month after. These annual and three month average BTSCC were transformed using natural logarithm transformation to normalize the distribution of this dependent variable (Figure 3).

The Provincial Dairy Laboratory reports bulk-tank standard plate counts as <30,000 cells/ml, the actual count between 30,000 and 300,000 cells/ml or >300,000 cells/ml. Most observations were <30,000 cells/ml. APHIN central database was used to generate similar annual and three month average bulk-tank standard plate counts while substituting a value of 30,000 when <30,000 was reported and a value of 300,000 when >300,000 was reported. For each inspection score, a count of each of these substitutions was also generated by APHIN. Because these average standard plate counts were not normally distributed, the data were used to create a

Figure 3. Distribution of continuous dependent variable Annual Average Bulk Tank Somatic Cell Count after natural log transformation with a normal (Gaussion) distribution curve superimposed.



dichotomized variable (high standard plate count). If at least one standard plate count was >300,000 cells/ml during the period, the variable was given a score of 1; otherwise it was scored as 0.

The APHIN central database was also used to generate a count of the positive inhibitor test results for each producer during these same time periods. This data was used to create a dichotomized variable (inhibitor). If there was at least one positive inhibitor test result during the calendar year that the inspection was done, the variable was given the score of 1; otherwise it was scored as 0. These dependent variables are described in Table VI.

4.2.2 Statistical analysis

Analyses were performed using SAS (45) and STATISTIX (31) statistical software. Descriptive statistics were performed using Proc Freq and Proc Univariate procedures. Categorical response variables (high standard plate count and bacterial inhibitors) were analyzed for associations with facility and sanitation scores using multivariable logistic regression (Proc Logistic) to create predictive models for high standard plate counts and positive inhibitors. STATISTIX was used to calculate odds ratios and the Hosmer-Lemeshow goodness of fit statistic for these models. The continuous variable, natural log of average somatic cell count, was analyzed using multiple linear regression (Proc Reg and Proc GLM) to create predictive models for average bulk-tank somatic cell counts.

Table VI Dependent variables analyzed using logistic and linear regression.

Variable Name	Variable Description
LNSCCYR	Continuous variable for natural log of the average bulk tank somatic cell count during the calendar year in which the dairy farm inspection was done.
LNSCC3M	Continuous variable for natural log of the average bulk tank somatic cell count during a three month period around the inspection date (the month the dairy farm inspection was done plus the month before and the month after).
HSPCYR	Dichotomous variable for high bulk tank standard plate count (0=no standard plate count > 300,000 during the year, 1=at least one bulk tank standard plate count > 300,000 during the year)
HSPC3M	Dichotomous variable for high bulk tank standard plate count (0=no standard plate count > 300,000 during the three months around the inspection date, 1=at least one bulk tank standard plate count > 300,000 during the three months around the inspection date)
INHIBYR	Dichotomous variable for bulk tank bacterial inhibitor (0=no positive disc assay test results during the year, 1=at least one positive disc assay test result during the year.
INHIB3M	Dichotomous variable for bulk tank bacterial inhibitor (0=no positive disc assay test results during the three months around the inspection date, 1=at least one positive disc assay test result during the three months around the inspection date.

4.2.3 Model Building

Predictor variables considered for inclusion in the models included the dairy farm inspection scores (variables of interest) listed in Table VII, plus other possible confounding variables listed in Table VIII. A three step process was followed in the development of all models.

Step one was designed to reduce the number of variables of interest for consideration in the models. Variables of interest and possible confounders were selected using stepwise regression with terms allowed to enter and leave the model if the Log likelihood χ^2 test (logistic regression models) or the partial F test or multiple partial F test (linear regression models) was significant with alpha set at 0.15 for entry and removal. Possible confounders removed by the stepwise regressions were assessed for confounding by removing each one from the full model and observing the impact of their removal on the value of the coefficients of the factors of interest. If a coefficient change was greater than 50%, the term was forced into the model and the stepwise selection repeated.

Step two was to identify possible two-way interactions for consideration in the model. All two-way interactions between possible confounders and inspection scores, selected in step one, and all two-way interactions among these inspection scores were considered. Using stepwise regressions with all original possible confounders and the reduced number of main effects forced in the model, interaction terms were allowed to enter and leave the model if the Log likelihood χ^2 test or the partial F test or multiple partial F test was significant with alpha set at 0.15 for entry and removal.

Table VII Predictor variables of interest considered for inclusion in logistic and linear regression analysis.

Variable Name	Variable Description
FGEN	Facilities - General Score (continuous variable, range 0 - 10)
FMHOUSE	Facilities - Milkhouse Score (continuous variable, range 0 - 30)
FSTORE	Facilities - Storage and Washing Facilities Score (continuous variable, range 0 - 30)
FBARN	Facilities - Milking Barn or Milking Parlour Score (continuous variable, range 0 - 30)
SGEN	Sanitation - General Score (continuous variable, range 0 - 8)
SCATTLE	Sanitation - Cattle Cleanliness Score (continuous variable, range 0 - 7)
SMHOUSE	Sanitation - Milkhouse Score (continuous variable, range 0 - 15)
SEQUIP	Sanitation - Equipment Interior and Exterior Cleanliness Score (continuous variable, range 0 - 43)
SBARN	Sanitation - Milking Barn or Milking Parlour Score (continuous variable, range 0 - 27)

Table VIII Independent variables considered for inclusion as possible confounders in logistic and linear regression analysis.

Variable Name	Variable Description
PARLOUR	Dichotomous Variable for milking area score (0=milking barn, 1=milking parlour)
HOUSING	Class Variable for type of housing (1=chain tie, 2=free stall, 3=loose, 4=stanchion)
INSPEC	Class Variable (1 - 4) for inspector identification
INDUST	Dichotomous Variable for producer type (0=fluid, 1=industrial)
ADL	Dichotomous Variable for milk purchaser-shipper (0=Milk Marketing Board, 1=Amalgamated Dairies Ltd.)
MONTH	Class Variable (1 - 12) for the month the dairy farm inspection was done
YEAR	Continuous variable for the number of years after the base year 1989 (range 0 to 3).

As a third step, models were further refined using both forward and backward selections with alpha set at 0.05 for entry or removal. All predictors that were a component of interactions selected in step two and all possible confounders, with the exception of PARLOUR (see section 3.3.1), were forced into the final models.

Multicollinearity among the inspection scores, possible confounders and interaction terms was evaluated by calculating the variance inflation factor for each independent variable (46). Sample-based multicollinearity was corrected by deleting redundant information. Structural multicollinearity was corrected by centering the measured independent variables on their mean values before interaction (cross-product) terms were calculated. In this case, the independent variables in the regression equation were replaced with their deviation from their mean as described by Glantz and Slinker (46).

4.2.4 Model evaluation

The Hosmer-Lemeshow goodness-of-fit χ^2 statistic was used to assess the fit of logistic regression models and the R^2_{adj} was used for the linear regression models. Regression diagnostics carried out on each of the final models included the examination of studentized residuals, leverages and Cook's distance and examination of plots of these against predicted values.

The linear regression model was applied to the 1992 data to predict average annual bulk-tank somatic cell counts using independent variables in this data set. Predicted and actual values were compared. The cross-validation correlation

(correlation between the 1992 predicted and observed values) and shrinkage on cross-validation (the difference between the R^2 of the predictive model and the square of the cross-validation correlation) were determined as an assessment of the reliability of the model (47).

The logistic regression model was applied to the 1992 data to predict the occurrence of at least one high bulk-tank bacterial count during the year. The sensitivity and specificity of the model prediction were determined to assess the ability of the model to predict future performance.

4.3 Results

Although analysis was done on both a 1 year and a 3 month prediction period, only the results based on the 1 year time period are presented and discussed. The 3 month models were very similar to the 1 year models and provide little additional information; they are included in Appendix H for comparison purposes.

4.3.1 Descriptive Statistics

The four years of data were contained in 1604 records. This included 1265 records for 1989 to 1991 (488, 392 and 385 respectively) used to develop the models and 339 records for 1992 used to evaluate the models. Descriptive statistics for the inspection scores and the distribution of the records are presented in Table IX and Table X respectively. Descriptive statistics for the bulk-tank food safety and quality parameters are presented in Table XI.

Table IX. Descriptive statistics of the Dairy Farm Inspection Scores.

<u>1989 - 1991 (model building)</u>

	Maximum Possible	Mean	SD	Median	Range
FACILITIES					
General	10	8.92	1.04	9	2 - 10
Milkhouse	30	27.15	2.28	28	16 - 30
Storage	30	28.89	1.76	30	16 - 30
Milking Area	30	28.74	2.39	30	15 - 30
(dairy barn)		28.75	2.46	30	15 - 30
(parlour)		28.69	1.66	29	22 - 30
SANITATION					
General	8	7.30	1.08	8	2 - 8
Cattle Cleanliness	7	6.23	1.32	7	1 - 7
Milkhouse	15	12.17	2.53	13	1 - 15
Equipment	43	37.60	5.52	39	11 - 43
Milking Area	27	23.38	3.50	24	7 - 27
(dairy barn)		23.44	3.40	24	7 - 27
(parlour)		22.80	4.29	24.5	8 - 27

<u>1992 (model testing)</u>

	Maximum Possible	Mean	SD	Median	Range
FACILITIES					
General	10	9.00	1.02	9.5	4 - 10
Milkhouse	30	27.30	2.16	28	17 - 30
Storage	30	29.09	1.61	30	20 - 30
Milking Area	30	28.89	2.53	30	14 - 30
(dairy barn)		28.85	2.65	30	14 - 30
(parlour)		29.08	1.06	29	26 - 30
SANITATION					
General	8	7.42	1.04	8	2 - 8
Cattle Cleanliness	7	6.29	1.22	7	1 - 7
Milkhouse	15	12.47	2.55	13	1 - 15
Equipment	43	37.81	5.03	39	15 - 43
Milking Area	27	23.62	3.45	24.5	7 - 27
(dairy barn)		23.60	3.54	24.5	7 - 27
(parlour)		23.83	2.73	24.5	15 - 27

Table X. Distribution of Dairy Farm Inspection records by possible confounders considered in the model.

		1989-91		1992	
		records n=1265	percent	records n=339	percent
INSPECTOR	#1	337	26.6	113	33.3
	#2	221	17.5	5	1.5
	#3	379	30.0	125	36.9
	#4	328	25.9	96	28.3
MONTH	Jan	96	7.6	16	4.7
	Feb	82	6.5	17	5.0
	Mar	76	6.0	11	3.2
	Apr	107	8.5	25	7.4
	May	133	10.5	36	10.6
	Jun	87	6.9	36	10.6
	Jul	104	8.2	59	17.4
	Aug	110	8.7	15	4.4
	Sep	165	13.0	33	9.7
	Oct	170	13.4	21	6.2
	Nov	87	6.9	35	10.3
	Dec	48	3.8	35	10.3
YEAR	0 (1989)	488	38.6		
	1	392	31.0		
	2	385	30.4		
	3			339	100
MILKING	barn	1138	90.0	300	88.5
	parlour	127	10.0	39	11.5
HOUSING	stanchion	747	65.8	121	37.8
	chain tie	271	23.9	165	51.1
	free stall	108	9.5	35	10.8
	loose	10	0.9	2	0.6
PRODUCER	fluid	566	44.7	219	64.6
	industrial	699	55.3	120	35.4
SHIPPER	ADL	702	55.5	289	85.3
	MMB	563	44.5	50	14.7
FARMS WITH REPEAT INSPECTIONS					
	1 inspection	297	42.8	339	100
	2 inspections	223	32.1		
	3 inspections	174	25.1		

Table XI. Descriptive statistics of the bulk tank food quality and safety parameters (dependent variables) used for model building and evaluating.

AVERAGE SOMATIC CELL COUNTS[a] (1000's)

	Mean	SD	Median	Range
1989-91	339	232	273	50 - 2471
1992	299	192	249	61 - 1416

	Frequency	%
HIGH STANDARD PLATE COUNT[b]		
1989-91	435	34.4
1992	40	11.8
ANTIBACTERIAL INHIBITOR[c]		
1989-91	21	1.7
1992	9	2.7

a Average bulk tank somatic cell counts for the calendar year in which the inspection was done.

b Farms with at least one standard plate count over 300,000.

c Farms with at least one positive disc assay test for bacterial inhibitors.

Sample-based multicollinearity was evident among the independent variables for type of housing (HOUSING) and milking area (PARLOUR). Correlation between free stall housing and milking parlour was 0.91 and variance inflation factors were in the order of 10. Most farmers tied cows in the barn, 90% were in stanchions or chain ties. Only 10% of farms housed cows in free stalls or loose housing. This corresponded with the 10% that milked in a parlour as opposed to milking in the barn. This redundant information resulted in multicollinearity among the variables HOUSING and PARLOUR. The variable HOUSING had 4 possible values and PARLOUR only two. The variable PARLOUR was not a significant predictor in either model, showed no evidence of being a confounder, and was providing redundant information. The variable was deleted to correct the multicollinearity.

Structural multicollinearity was evidenced by high variance inflation factors (50 to 150) after the introduction of cross product interaction terms. Centering effectively eliminated this multicollinearity.

4.3.2 Bulk-tank Somatic Cell Count

The final model for the natural log of annual average bulk-tank somatic cell count is presented in Table XII (the detailed model is in Appendix H). After correction for possible confounding effects, the model contained the five sanitation scores (SGEN, SCATTLE, SMHOUSE, SEQUIP and SBARN) and six interaction terms (MONTH*SMHOUSE, INSPEC*SMHOUSE, INSPEC*SBARN, INDUST*SCATTLE, INDUST*SBARN and INDUST*YEAR). This model was

Table XII. Prediction of average annual bulk tank somatic cell count using regression analysis for dairy farm inspection scores of facilities and sanitation.

Predictor	df	Coefficient	S.E.	p-value
INTERCEPT		10.534	0.699	0.000
Main Effects				
SGEN	1	-0.089	0.017	0.000
SCATTLE	1	-0.098	0.028	0.001
SMHOUSE	1	-0.190	0.044	0.000
SEQUIP	1	-0.017	0.004	0.000
SBARN	1	-0.020	0.015	0.188
Possible Confounders				
ADL	1	-0.060	0.046	0.195
industrial	1	0.027	0.066	0.686
inspector	3			0.004
housing	3			0.196
month	11			0.088
year	1	-0.106	0.033	0.001
Interactions				
smhouse*inspector	3			0.000
smhouse*month	11			0.002
industrial*scattle	1	0.091	0.030	0.002
industrial*year	1	0.084	0.040	0.037
sbarn*industrial	1	0.042	0.013	0.001
sbarn*inspector	3			0.007

$R^2 = 0.27$ Adjusted $R^2 = 0.25$ n = 1265 significant ($F_{44,1214}$=10.15, p=0.00) but only explained 25% (R^2_{adj}) of the variance in the yearly average somatic cell count. All main effects predict a downward trend in bulk-tank SCC as the sanitation improves.

4.3.3 Bulk-tank Standard Plate Count

The predictive model for at least one high standard plate count during the year is presented in Table XIII. The score for equipment sanitation (SEQUIP) was the only significant predictor of interest that remained in the final model. As the equipment sanitation score improved from 0 to 43, with every increase of 1 unit in the equipment sanitation score, the probability of a high standard plate count was very slightly reduced (OR=0.94 with 95% confidence interval of 0.91 to 0.96). The score for milkhouse sanitation had no predictive significance alone (OR=1.04 with 95%confidence interval of 0.92 to 1.19) but an interaction between this score and class of producer (SMHOUSE*INDUST) was identified. With each unit increase in the milkhouse sanitation score from 0 to 15, the probability of having a high standard plate count was reduced only on farms producing industrial milk (OR=0.85 with 95% confidence interval of 0.74 to 0.98). The Hosmer-Lemeshow goodness of fit test statistic of 3.44 (p=0.90) gives us no reason to believe the model does not fit these data.

4.3.4 Bacterial inhibitor

The logistic regression would not converge because of the relatively small

Table XIII. Logistic regression model for the prediction of at least one high bulk tank bacterial count during the year using dairy farm inspection scores of facilities and sanitation.[a]

Predictor	Coefficient	Odds Ratio	p-value
Intercept	1.349		0.175
SEQUIP	-0.064	0.94	0.000
SMHOUSE	0.043	1.04	0.521
SMHOUSE*INDUST	-0.157	0.85	0.029
Industrial	1.292	3.64	0.000
ADL	-0.493	0.61	0.011
Inspector 1	-0.359	0.70	0.089
Inspector 2	-0.332	0.72	0.116
Inspector 3	-0.573	0.56	0.004
Inspector 4	0.000	1.00	
housing free stall	-0.102	0.90	0.698
housing loose	-0.037	0.96	0.959
housing chain tie	0.066	1.07	0.739
housing stanchion	0.000	1.00	
Month 1	-0.003	1.00	0.994
Month 2	-0.057	0.94	0.882
Month 3	-0.677	0.51	0.122
Month 4	-0.094	0.91	0.811
Month 5	-0.275	0.76	0.469
Month 6	-0.130	0.88	0.751
Month 7	0.019	1.02	0.962
Month 8	-0.261	0.77	0.513
Month 9	-0.509	0.60	0.174
Month 10	-0.444	0.64	0.235
Month 11	-0.322	0.72	0.440
Month 12	0.000	1.00	
Year	-0.190	0.83	0.048

[a] Hosmer-Lemeshow goodness-of-fit statistic = 3.44 (p = 0.90)

number of positive inhibitor results (21 positive tests for inhibitor out of 1265 records).

4.3.5 Model evaluation

The residual analysis carried out on the final models did not reveal unusual observations, observations with undue influence or departure from linearity assumptions. The prediction error for the 1992 predicted BTSCC was quite large with a mean of 278 (1000's cells/ml) and a standard deviation of 632 (1000's cells/ml). Although the predictive ability of the model is poor, the model performed almost as well predicting 1992 results as it did in predicting the 1989-91 results (i.e. the results from the years from which the model was built). This is evidenced by a cross-validation correlation of 0.44 between the 1992 predicted and observed values and by the shrinkage on cross-validation of 0.06 (the difference between $R^2 = 0.25$ for the predictive model and cross-validation $R^2 = 0.19$).

The logistic model was insensitive when predicting high bulk-tank bacterial counts. At the commonly used probability threshold of 0.5 the sensitivity of the model was 44% and the specificity was 85% (i.e. only 44% of the farms that actually did have a high standard plate count during 1992 were identified by the model; on the other hand the model correctly identified 85% of the farms which did not have a high standard plate count). The sensitivity and specificity of the model for various probability thresholds is presented in Table XIV.

Table XIV. Sensitivity and specificity of the logistic regression model when classification as high standard plate count was done at various probability thresholds.

Threshold probability	1992 sensitivity %	1992 specificity %
0.2	88	37
0.3	74	60
0.4	50	74
0.5	44	85
0.6	28	92
0.7	16	96

4.4 Discussion

The objective of the study was to determine the ability of dairy farm facilities and sanitation, as scored by the Prince Edward Island Department of Agriculture inspectors, to predict three food safety and quality bulk-tank parameters (somatic cell count, standard plate count and antimicrobial residue). This was accomplished through linear and logistic regression analysis of the inspection scores on the bulk-tank parameters. Significant interactions and possible confounders were considered by their inclusion in the models. To ensure any demonstrated predictive ability of the inspection scores occured only after any confounding had been considered, potential confounders were retained in the final models.

Multicollinearity can cause problems in interpreting regression coefficients. By removing redundant information and centering data, multicollinearities, as measured by variance inflation factors, were eliminated. For predictive models, multicollinearity is not a concern provided the data used for prediction have the same multicollinearity and range as the data used to estimate the original model. One would expect this to be the case for subsequent years inspection data but because multicollinearity was effectively handled, these factors were no longer a concern. Although the objective was to develop predictive models, the effective handling of multicollinearity also meant the coefficients could be considered when associations were interpreted.

4.4.1 Descriptive statistics

The 1265 records used to build the predictive models represented three years of inspection data. Some inspections were repeated on the same farm. Those inspection scores might be expected to be more highly correlated than completely independent observations. This clustering would not bias the estimates of the coefficients in the models but would artificially reduce the estimates of their standard errors. This could lead to inflated estimates of the statistical significance of the factors of interest. Over 40% of the observations were independent (i.e. only one record per farm) and any repeat inspections on the same farm were done at least one year apart. Considering this, clustering was not viewed as a major concern and no attempt was made to correct for it.

The mean and median of the facility scores observed were at or near the maximum scores and most scores were within the top 50% of possible scores. These data indicate that most farms in Prince Edward Island have facilities considered adequate by the Provincial Department of Agriculture. Sanitation scores were distributed over a much larger range and the mean and median were not as close to the maximum possible score compared to facility scores. Sanitation was much more variable on dairy farms in Prince Edward Island.

4.4.2 Bulk-tank somatic cell count

Sanitation levels of the dairy barn and equipment were significant predictors of average bulk-tank somatic cell counts but only 25% of the variability seen in the average BTSCC could be explained with this model. All five sanitation scores plus interaction terms representing interactions among sanitation scores, inspector, class of producer and month of the year were retained in the final model for predicting annual average bulk-tank somatic cell count. The sanitation score SBARN was not significant ($p=0.188$) but was a component of significant interactions and therefore retained. Coefficients of the sanitation scores were all negative indicating a downward trend in BTSCC as sanitation improved.

There was an interaction between inspectors and two inspection scores (inspector*smilkhouse, inspector*sbarn). This means that the relationship between BTSCC and these scores was different for each inspector. An increase in a milkhouse sanitation score from 12 to 15, for example, might decrease the predicted annual average BTSCC (1000's) from 156 to 94 for scoring by inspector #1, from 91 to 59 for scoring by inspector #2, from 337 to 197 for scoring by inspector #3 and from 407 to 192 for scoring by inspector #4. Inspection scoring was a subjective exercise, even with published guidelines, therefore this variation among inspector scoring was not unexpected. An increase in the inspection score from 12 to 15 probably reflected a different degree of improvement for each of the inspectors.

Two interaction terms (industrial*scattle and industrial*sbarn) indicated the sanitation scores for the cattle and the barn had a significantly different association with BTSCC on farms producing fluid milk as apposed to those producing industrial milk. The change in the predicted decrease in BTSCC was significantly greater for each unit increase in cattle and barn sanitation scores on farms producing fluid milk than on farms producing only industrial milk. There had been a downward trend to average BTSCC's since 1989 as indicated by the negative coefficient (-0.106) for YEAR. The positive interaction term INDUST*YEAR (coefficient 0.084) indicated this downward trend had been less for industrial producers. Similarly, the interaction term SMILKHOUSE*MONTH indicated the predicted lowering of the BTSCC per unit increase of the milkhouse sanitation score was different from one month to the next.

The final model performed as well in predicting the farm BTSCC with new data as it did with the original data. The cross-validation correlation between the predicted and observed values was 0.44 (R^2=0.19). The R^2 of the original model was 0.25 making the shrinkage on cross-validation very small (0.06). This indicated the model did almost as well predicting future performance as it did predicting current performance. However, the plot of predicted versus observed lnSCC, presented in Figure 4, indicated that overall the model was not a good predictor. The prediction error, presented in Figure 5, was usually within the range of ±200,000 but some errors were considerably larger, particularly for larger actual counts.

4.4.3 Bulk-tank standard plate count

The association between bulk-tank bacterial counts and equipment sanitation has been documented (33,34,35). The model, created using logistic regression, for predicting high standard plate counts support these findings. The sanitation score for equipment was the only significant inspection score retained in the final model. The

Figure 4. 1992 actual and predicted average annual BTSCC's in P.E.I.

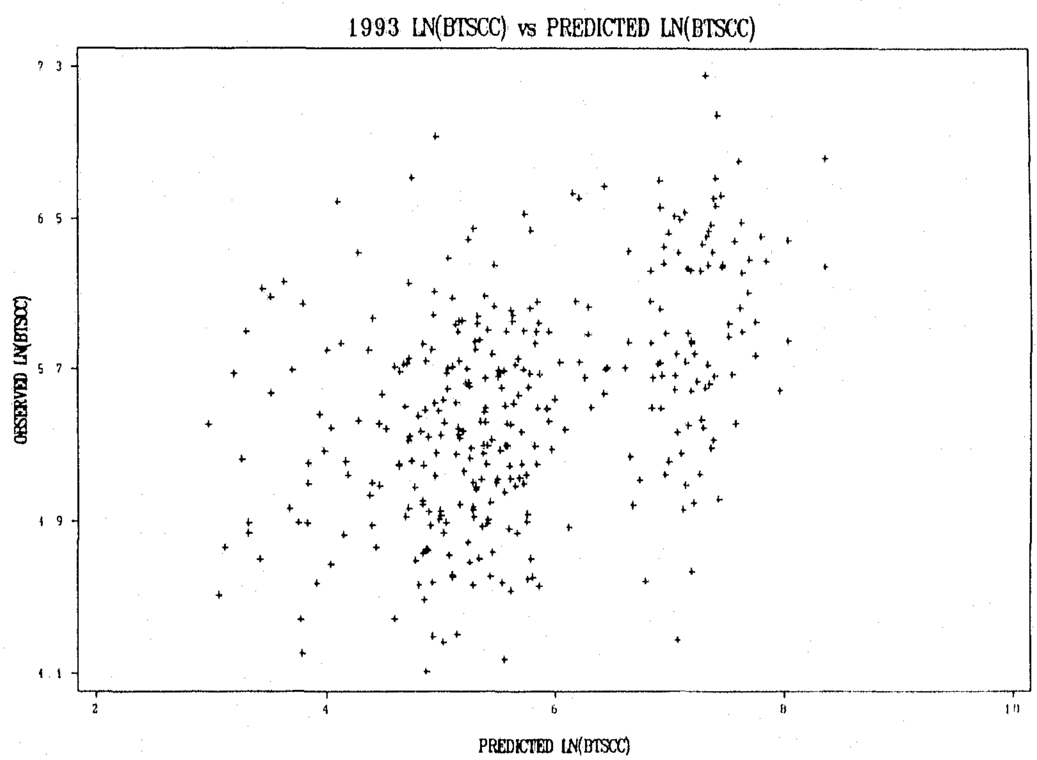
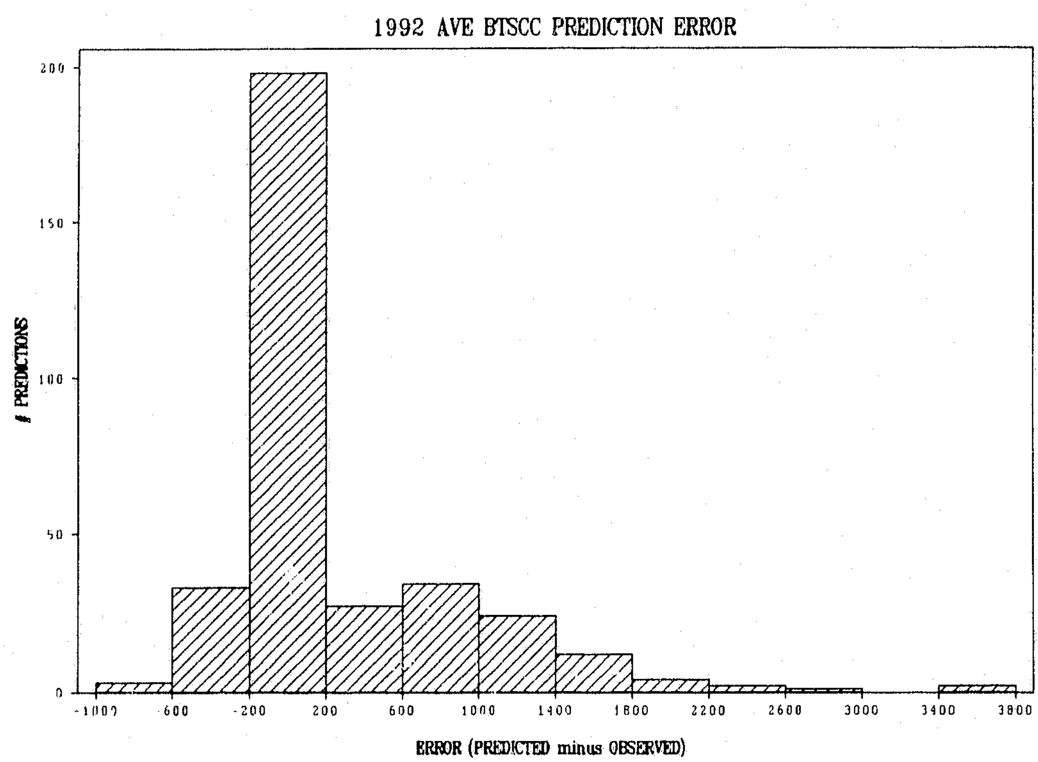


Figure 5. The prediction error in predicting P.E.I. annual average bulk tank somatic cell count for 1992.



class of producer, although not one of the main factors being examined, was notable. Regulations in Prince Edward Island tolerate larger bulk milk bacterial counts in industrial milk. This is reflected in the model with the odds of an industrial producer having a high bacterial count being 3.89 times greater than that of a fluid producer.

For the model to classify farms from the original data with a sensitivity of 60% and specificity of 74%, a threshold probability of >0.4 was set. With the 1992 data the sensitivity was 59% and specificity was 78% for the same threshold. Although the model might be judged a poor performer because of the relatively low sensitivity and specificity, it did predict future events with a sensitivity and specificity similar to that calculated with the original data.

4.4.4 Antimicrobial Residue

Although this study did not produce a predictive model for antimicrobial residue in bulk-tank milk, a recent study showed a strong interrelationship among milk quality parameters (43). Most likely, direct, causal links exist between these milk quality components. The single largest use for antimicrobial agents in dairy cows is for the treatment of mastitis (48). Herds with more mastitis problems may then be expected to have high bacterial counts, high SCC and require more antimicrobial treatments. These herds could, therefore, be expected to be at greater risk of positive inhibitors in bulk milk.

4.4.5 Conclusions

The fitted models may be utilized to estimate a predicted BTSCC or high SPC and indirectly, greater risk of inhibitory substances. Although the annual inspection scores did not make good predictors of annual average bulk-tank parameters and might not be very timely for interventions, there were significant associations found between sanitation inspection scores and bulk-tank food safety and quality parameters. By using these scores along with other management predictors and previous bulk-tank quality parameters, prediction of bulk-tank milk quality and safety parameters could probably be improved. When these predicted levels are too high, preventative measures could be applied before the regulatory limits are exceeded.

Further analysis of these, and other similar data, to quantify and qualify other associations observed, might provide additional insight into the dynamics of these food safety and quality parameters.

5. SUMMARY

5.1 A Feasibility Study

A study was conducted on P.E.I. to determine the feasibility of establishing a network of communication to monitor basic herd level animal health, productivity and food safety on dairy farms. A basic herd level system (HERD) which collected only herd level data and collected all data directly from the farm, was compared to an animal level system (ANIMAL) that collected animal and herd level data from various sources. Both concepts had the Federal District Veterinarian as the local coordinator of the system. The two systems were compared using a random sample of 12 dairy farms in P.E.I. A total of 18 farmers were contacted in order to find 12 that would participate. Farmers that utilized a regular herd health program through their veterinarian were more willing to participate. Farmers had very little difficulty adapting to the use of the recording forms provided and readily recorded information they felt would be of benefit to them but compliance was low for the transcribing of HERD data from other reports onto the data collection form. Time commitments (minutes/month/farm) to collect farm source data for either system appeared similar.

Both systems appear to be feasible as a base for a national animal productivity, health and food safety epidemiology network. Both systems have their advantages and disadvantages, however, the ANIMAL concept has considerable advantages over the HERD concept. Although the establishment of the original infrastructure for ANIMAL is more complex, the number of individual contacts required on a continual basis is much less than with HERD. The ability to utilize sophisticated health management software, to provide more data validation and hence more reliable data, and to do extensive analysis and reporting, all result in increased compliance by producers. Without producer compliance, any system would be of little value. The ANIMAL system facilitates communication between private and public veterinary practitioners, however, the direct contact between public veterinary practitioners and producers, required of the HERD system, is only an indirect contact through the private veterinarian with the ANIMAL system. The resources required at the District Office have not been fully assessed. It would appear that these resources would be similar for either system but would be used for different activities.

A working group of the National Expert Committee on Animal Health is to review the results of this feasibility study and make recommendations regarding the next phase.

5.2 Additional Food Safety Monitoring

The effect of freezing milk samples on the results of the standard plate count was compared to the variation observed with replicate fresh samples. Freezing tended to result in a slight reduction in the count but the range of change between fresh and frozen samples was within the variability observed between replicate fresh samples. The length of time samples were frozen had a significant but relatively small impact on the standard plate count. The increased frequency of bulk-tank testing from participating farms during the project did show isolated plate counts higher than normal for that farm but no sustained period of increasing bulk-tank standard plate counts was observed.

The additional weekly bulk-tank samples were all negative for antimicrobial residue when tested with the less sensitive disc assay procedure. A subset of 83 samples was tested using the LacTek sulfamethazine and β-lactam tests. Of these, three tested positive for sulfamethazine and two tested positive for β-lactam antibiotics. The corresponding five composite truck samples containing these five positive bulk-tank samples were also tested. Only one truck sample was positive. The milk from positive bulk-tanks was sufficiently diluted in the truck, with milk from other farms, to make the residue undetectable in four of five cases. These results would indicate that there is little benefit to be derived from more frequent testing but the use of more sensitive tests would increase detection of antimicrobial residue.

In an effort to track cull cows from farm of origin to slaughter, all participating farmers were asked to identify, with a particular ear tag, all cull cows leaving the farm. Only 10 of 92 cows were tagged leaving the farm. This low compliance indicates a voluntary animal identification system would not enable the tracing of positive meat residue test results from slaughter to the farm of origin.

5.3 Sanitation Predictors of Food Quality and Safety

Predictive models were developed that used dairy farm facilities and sanitation scores, as determined by the P.E.I. Department of Agriculture inspectors, for the prediction of bulk-tank somatic cell counts and high bulk-tank bacterial counts. Models were developed using data for 1989 to 1991 then validated by applying the models to 1992 data. Sanitation levels of dairy barns and equipment were significant predictors of average bulk-tank SCC. Significant interactions among sanitation scores, inspectors, class of producer and month of the year were represented in the final model. Coefficients of the sanitation scores were all negative indicating a downward trend in bulk-tank SCC as sanitation improved. The model performed as well predicting bulk-tank SCC with new data as it did with the original data.

The sanitation of equipment was the only significant predictor of high bulk-tank bacterial counts. Although not a significant predictor in the model, the odds of an industrial producer having a high bacteria count was 3.89 times greater than that of a fluid producer. The annual inspection scores, although significant predictors, did not make good predictors of annual average bulk-tank SCC or high bacterial counts.

Identification of poor quality or unsafe milk at the farm, before it enters the processing system, is desirable. The ability to predict the milk quality and safety parameters would enable the introduction of preventative measures when predicted parameters were too high. Significant associations were found between sanitation scores and bulk-tank food safety and quality parameters. Further analysis of these, and other similar data, and further research to quantify and qualify other associations, might improve the prediction of bulk-tank milk quality and safety parameters. Prevention of predicted problems, before regulatory limits are exceeded, would be possible.

APPENDIX A: Data collection forms

DATA RECORDING SHEET

DAIRY PRODUCTION, HEALTH AND FOOD SAFETY NETWORK - PILOT

Producer Name:_________________________ Month:___________

Bulk Tank SCC:___________ Last Day of Month

Plate Count: ___________ Cows Milking:_____ Cows Dry:_____

Milk Vol: ________ B.F. ______ Cow Additions this month:_____

Record all events including: calvings, heats, breedings, diseases & treatments, dry off dates, abortions, cullings, sales, registering calves, name changes etc.

Barn Name or #	Date	Event	Comment

MODIFIED DAIRY MONITOR AND ANALYSIS PROGRAM
FARM DATA COLLECTION SHEET

Milking Herd Only

Producer Name: ______________________________ Date: __________

Milk volume shipped: _______ _______ Fat: _______ _______

Bulk Tank...SCC: _________ Plate loop count: ________ ________

Calved
Cows: ____ Heifers: ____

Total Calves born: _________
Twin sets: ____ Born Dead: ____

Cows Bred 1st: ____
2nd: ____
3 +: ____

Total Cows Pregnancy Check: ________
INITIAL preg: ____ NOT pregnant: ____
RECHECK preg: ____ NOT pregnant: ____

Visible abortions: ____

COWS Clinical Disease

Clinical Mastitis: ____
Retained Placenta: ____
Treated Milk fever: ____
Treated for cysts: ____
Ketosis WITHOUT other disease: ____
Displaced abomasum: ____
Treated Respiratory disease: ____
Other disease: ____

Dry cows treated: ____ product used: ____

Total COWS Culled ____ Total COWS died:(____)

sold for dairy: ____
poor reproduction: ____
mastitis: ____

poor production: ____
poor feet & legs: ____
other reasons: ____

Cull cows tagged: ____ (Y/N)

INVENTORY

Cows Milking the last day of the month: ____
Cows Dry the last day of the month: ____
Cow additions (bought etc.) this month: ____

Vaccination Name: ____________________
Date: ____________________
Number of
Cows: ____ Heifers: ____

APPENDIX B: HERD Reports

MODIFIED DAIRY MONITORING AND ANALYSIS PROGRAM
12 Months: Sep to Aug, 1992
SUMMARY OF DATA FROM ON-FARM SHEETS

FARM: JOHN DOE
HERD Number: XXXX

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Cows calved	0	1	2	4	3	0	0	3	4	1	1	2
Heifers calved	0	2	2	3	2	1	2	0	2	2	0	0
Cows with twins	0	0	0	0	0	0	0	1	0	0	0	0
Stillbirths	0	0	0	0	0	0	0	0	0	0	0	0
Retained placentas	0	0	0	0	1	0	0	2	0	0	1	0
Cysts	0	0	0	0	0	0	0	0	0	0	0	0
Uterine infections	0	0	0	0	0	0	0	0	0	0	0	0
Cows bred	0	2	1	1	6	5	10	3	0	3	12	7
1st breedings	0	2	0	1	3	4	7	2	0	0	5	4
2nd breedings	0	0	0	0	3	0	3	1	0	3	3	2
3rd or more breedings	0	0	1	0	0	1	0	0	0	0	4	1
Cows for 1st preg check	3	2	4	0	0	0	4	0	0	8	0	4
Cows open at 1st check	4	1	3	0	0	6	6	0	0	6	2	3
Cows for preg recheck	0	3	1	0	2	0	0	0	0	1	0	0
Cows open at recheck	1	2	0	0	0	2	0	2	0	1	0	0
Cows aborted	0	1	0	0	0	1	0	0	0	0	0	0
Milk fever	0	1	0	0	0	0	0	0	0	0	0	0
Ketosis	0	0	0	0	0	0	0	0	0	0	0	0
Left displaced abomasum	0	0	0	0	0	0	0	0	0	0	0	0
Respiratory disease	0	0	0	0	0	0	0	0	0	0	0	0
Treatments for mastitis	0	0	1	1	0	3	1	2	3	0	0	0
Cows sold for dairy	0	0	0	0	0	0	0	0	0	0	0	0
Cows sold for poor repro	1	0	1	0	0	0	0	0	0	0	0	0
Cows sold for mastitis	0	0	0	0	0	0	0	0	0	0	0	0
Cows sold for poor prod	1	0	0	0	0	0	0	0	0	0	0	0
Cows sold for poor feet	1	0	0	0	0	0	0	0	0	0	0	0
Cows sold for other	0	0	0	0	0	0	0	2	0	1	0	0
Cows died	0	0	0	0	0	1	0	0	0	0	0	0
Culled Cows Tagged	0	0	0	0	0	0	0	2	0	0	0	0
Number Dry Treated	0	0	3	0	2	1	0	0	1	0	0	0
Total Milk Shipped	14	13454	13663	17803	21746	21608	22556	24101	24101	23790	24023	23137
Average Butterfat	36.10	35.90	38.08	39.80	38.55	37.75	36.63	37.80	36.80	37.25	36.50	36.40
Stan Plate Count	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
2nd Stan Plate Count	30000	30000	30000	30000	30000	30000	30000	30000	30000	58000	0	0
Bulk tank SCC	96000	100000	103000	68000	68000	79000	66000	60000	63000	141000	0	0
No. cows vaccinated	0	0	0	0	31	0	0	0	0	0	0	0
No. heifers vaccinated	0	0	0	0	26	0	0	0	0	0	0	0

MODIFIED DAIRY MONITORING AND ANALYSIS PROGRAM

Report: Sep, 1991 to Aug, 1992

FARM: JOHN DOE
HERD Number: XXXX

SUMMARY INFORMATION FROM ON-FARM DATA SHEETS

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Cows calved each month	0	1	2	4	3	0	0	3	4	1	1	2
Heifers calved each month	0	2	2	3	2	1	2	0	2	2	0	0
TOTAL CALVING	0	3	4	7	5	1	2	3	6	3	1	2
Percent calving with:												
TWINS	N/A	0	0	0	0	0	0	33	0	0	0	0
STILLBIRTH	N/A	0	0	0	0	0	0	0	0	0	0	0
RETAINED PLACENTA	N/A	0	0	0	20	0	0	67	0	0	100	0
METRITIS	N/A	0	0	0	0	0	0	0	0	0	0	0
Percent of Cows Treated for:												
MILK FEVER	N/A	100	0	0	0	N/A	N/A	0	0	0	0	0
KETOSIS	0	0	0	0	0	0	0	0	0	0	0	0
L.D.A.	0	0	0	0	0	0	0	0	0	0	0	0
RESPIRATORY DISEASE	0	0	0	0	0	0	0	0	0	0	0	0
Percent of Cows Pregnant at:												
1ST PREGNANCY CHECK	43	67	57	N/A	N/A	0	40	N/A	N/A	57	0	57
PREGNANCY RE-CHECK	0	60	100	N/A	100	0	N/A	0	N/A	50	N/A	N/A

APPENDIX C: DairyCHAMP Reports

ANIMALS DUE TO CALVE
1 SEP 92 - 12 OCT 92
FARM: FARM #6

DairyCHAMP 1.1
Copyright 89 Univ of Minn
Printed: 1 SEP 92

Animal ID	Lact	Est days dry	Days to pred. calving	Due to calve on	Problem last calving	Location	Calf Sire
ALANA	1			UNKNOWN			
FRANCES	1		11	12 SEP 92			NERF
BUTTERCUP	4		25	26 SEP 92			STARBUCK
DOLLY	0		25	26 SEP 92			LEADMAN
GRACIE	0		25	26 SEP 92			BROKER
ABBY	0		25	26 SEP 92			STARBUCK
CANDI	0		32	3 OCT 92			PETE TIDY
LESLIE	0		40	11 OCT 92			MARLIN

8 animal(s) reported.

ANIMALS DUE TO DRY OFF
1 SEP 92 - 12 OCT 92
FARM: FARM #6

DairyCHAMP 1.1
Copyright 89 Univ of Minn
Printed: 1 SEP 92

Animal ID	Lact	Expected Dry Date	Mastitic Quarters	# Clinical Mastitis	Treatments (Not Mast)	# Disease	Prod Index	Ave SCC *1,000	Location
FRANCES	1	19 JUL 92		0	1	0			
BUTTERCUP	4	2 AUG 92		0	0	0		178	
CHRISTINA	1	25 AUG 92		0	0	0		168	
LUCILE	4	25 AUG 92		0	0	0		680	
RACHEL	2	1 SEP 92		0	0	0		61	

LF - Left front quarter RF - Right front quarter
LR - Left rear quarter RR - Right rear quarter

5 animal(s) reported.

ANIMALS DUE IN HEAT
1 SEP 92 - 12 OCT 92
FARM: FARM #6

DairyCHAMP 1.1
Copyright 89 Univ of Minn
Printed: 1 SEP 92

Animal ID	Repro stat	Due in heat	Next heat expected	Reasons	Location
KATHERINE	BRED	3 SEP 92	24 SEP 92	PREVIOUS HEAT	
JOAN	BRED	5 SEP 92	26 SEP 92	PREVIOUS HEAT	
RAMA	BRED	6 SEP 92	27 SEP 92	PREVIOUS HEAT	
DOT	BRED	11 SEP 92	2 OCT 92	PREVIOUS HEAT	
LINDA 268	BRED	13 SEP 92	4 OCT 92	PREVIOUS HEAT	
JULIE	BRED	13 SEP 92	4 OCT 92	PREVIOUS HEAT	
LINDA 73	BRED	13 SEP 92	4 OCT 92	PREVIOUS HEAT	
MATTI	BRED	14 SEP 92	5 OCT 92	PREVIOUS HEAT	

8 animal(s) reported.

ANIMALS NOT YET PREGNANT
1 SEP 92 - 12 OCT 92
FARM: FARM #6

DairyCHAMP 1.1
Copyright 89 Univ of Minn
Printed: 1 SEP 92

Animal ID	Lact	Calving date	Date start breeding	Days open	Repro stat	Location
MILAS GIRL	1	26 SEP 91	26 OCT 91	341	BRED	
RAMONA RED	3	23 OCT 91	22 NOV 91	314	BRED	
JULIE	5	18 JAN 92	17 FEB 92	227	BRED	
SPARTAN EVA	1	24 JAN 92	23 FEB 92	221	CALVED	
JOAN	5	8 MAR 92	7 APR 92	177	BRED	
HESTER	4	13 MAR 92	12 APR 92	172	CALVED	
KAREN	6	30 MAR 92	29 APR 92	155	CALVED	
KATHERINE	6	29 APR 92	29 MAY 92	125	BRED	
RAMA	2	12 MAY 92	11 JUN 92	112	BRED	
REWARD JUNE	2	19 MAY 92	18 JUN 92	105	CALVED	
KATLYN	2	1 JUL 92	31 JUL 92	62	CALVED	
CECILE	2	1 JUL 92	31 JUL 92	62	CALVED	
BELLA	3	6 JUL 92	5 AUG 92	57	CALVED	
VAL	4	7 JUL 92	6 AUG 92	56	CALVED	
VIKKI	2	4 AUG 92	3 SEP 92	28	CALVED	
JANICE	4	9 AUG 92	8 SEP 92	23	CALVED	
EVA (BREEZE)	5	10 AUG 92	9 SEP 92	22	CALVED	

27 animal(s) reported.

BREEDING WORK LIST
1 SEP 92
FARM: FARM #6

DairyCHAMP 1.1

Printed: 1 SEP 92

ID	STATUS	REPRO TREATMENT	HEAT INTV	DIM	#H	#B	DAYS BRED LAST	PREV	LAST SIRE
ALANA	PREGNA	24JUN,PGF	165	258	2	1	165		CONQUEST
AMY	PREGNA		160	225	1	1	160		MERCER
BELLA	CALVED			57	0	0			
BETSIE	PREGNA	25MAR,PGF	133	226	2	1	133		PRELUDE
BETTY	BRED		46		1	1	46		CONQUEST
BRIDGET	BRED		162		1	1	162		GERALDO
BUTTERCUP	PREGNA	13DEC,PGF	260	357	2	1	260		STARBUCK
CANDI	PREGNA	7DEC,PGF	253		3	1	253		PETE TIDY
CARLA	PREGNA	27MAY,PGF	92	184	2	1	92		PRELUDE
CECILE	CALVED			62	0	0			
CHANTEL	BRED		168		1	1	168		GERALDO
CHITA	TBC		328	486	2	2	328	390	DARK STAR
CHRISTINA	PREGNA		237	356	3	2	237	301	RAIDER
CINDY	PREGNA		37	184	1	1	37		AEROSTAR
DH-ROY	PREGNA		178	245	1	1	178		STARBUCK
DOLLY	PREGNA	7DEC,PGF	260		4	2	260	350	LEADMAN
DOT	BRED		32		1	1	32		INSPIRATI
EMILY	PREGNA		185		1	1	185		PRELUDE
EMMA	BRED		260		1	1	260		INSPIRATI
EVA (BREEZE)	CALVED			22	0	0			
FRANCES	PREGNA	1OCT,ANTI	274	525	5	4	274	337	NERF
GRACIE	PREGNA		260		1	1	260		BROKER
HESTER	CALVED			172	0	0			
INGRID	TBC	13MAR,ANTI	92	406	7	5	92	112	MADISON
JANICE	CALVED			23	0	0			
JOAN	BRED	14JUN,PGF	17	177	3	3	17	46	ASTRE
JULIE	BRED		30	227	6	6	30	50	NORMUDE
KAREN	CALVED			155	0	0			
KATHERINE	BRED	24JUN,PGF	19*	125	3	2	19	62	LINCOLN
KATLYN	CALVED	31JUL,PGF		62	1	0			
LESLIE	PREGNA	7DEC,PGF	245		4	2	245		MARLIN
LINDA 268	BRED	24JUN,PGF	30		3	2	30	94	CONQUEST
LINDA 73	BRED	29JUL,PGF	30		2	2	30	46	CONQUEST
LUCILE	PREGNA		237	376	1	1	237		RAIDER
MARCY	BRED		260		1	1	260		INSPIRATI
MATTI	BRED		29		1	1	29		RAYMOND
MILAS GIRL	BRED	7DEC,PGF	228	341	4	2	228	252	STEWART
PAM	PREGNA	27MAY,PGF	94		1	1	94		CLYDE
RACHEL	PREGNA		230	295	1	1	230		STARBUCK
RAMA	BRED		16	112	2	2	16	41	AEROSTAR
RAMONA RED	BRED	26FEB,PGF	45	314	6	6	45	67	ONYXAR
RAPTURE	PREGNA		71	135	1	1	71		PRELUDE
REBA	PREGNA		131	254	2	2	131	153	PRELUDE
ROBYN	PREGNA	7DEC,PGF	242		3	1	242		MANDINGO

```
SELECTION LIST FOR VETERINARIANS                                    DairyCHAMP 1.1
1 SEP 92                                                   Copyright 89 Univ of Minn
FARM: FARM #6                                                   Printed:  1 SEP 92

Selection List For Cows
                                                                  DAYS BRED PROD
ID                   REASON  STATUS LAST EXAM               DIM DCC #H #B LAST PREV INDEX
-------------------- ------- ------ ----------------------- --- --- ----- --------- ------

HESTER               NVH     CALVED                         172      0  0
  13 MAR 92;CALVED;1;0;0;0;

JOAN                 FTC(>3) BRED   27MAY,,L:CH1,,          177      3  3  17   46
   8 MAR 92;LABORT;;;TWIN BULLS                   17 JUN 92;AI;;INSPIRATIO;;;;1.00;;
  27 MAY 92;RECTAL;;;L:CH1;;;                     17 JUL 92;AI;;AEROSTARIO;;;;1.00;;
  27 MAY 92;REMARK;PG IN 7 DAYS                    6 AUG 92;CHANGE ID;JOAN
  14 JUN 92;CONTROL HEAT;PGF PRODUCT;             15 AUG 92;AI;;ASTRE;;;;1.00;;

JULIE                OP165   BRED                           227      6  6  30   50
  18 JAN 92;CALVED;2;0;2;0;                       14 MAY 92;AI;;RAIDER;;;;1.00;;
  18 JAN 92;CALF ID;JULIE-92T1;FEMALE;             3 JUN 92;AI;;IGLOO;;;;1.00;;
  18 JAN 92;CALF ID;JULIE-92T2;FEMALE;            22 JUN 92;AI;;IGLOOR;;;;1.00;;
   1 APR 92;AI;;RAIDER;;;;1.00;;                  13 JUL 92;AI;;STORMY;;;;1.00;;
   2 APR 92;AI;;RAIDER;;;;1.00;;                   2 AUG 92;AI;;NORMUDE;;;;1.00;;

KAREN                NVH     CALVED                         155      0  0
  30 MAR 92;CALVED;1;0;0;0;

MILAS GIRL           NER     BRED                           341      3  2 228  252
  26 SEP 91;CALVED;1;0;0;0;                       24 DEC 91;AI;;RAIDER;;;;1.00;;
  22 NOV 91;HEAT;TOO EARLY;;                      17 JAN 92;AI;;STEWART;;;;1.00;;
   7 DEC 91;CONTROL HEAT;PGF PRODUCT;

RAMONA RED           PD      BRED   24JUN,,,,               314      6  6  45   67
  23 OCT 91;CALVED;1;1;0;0;                       20 APR 92;AI;;BROKER;;;;1.00;;
  26 FEB 92;RECTAL;;;L:CL1;;;                     27 MAY 92;PREGNANT;;;
  26 FEB 92;CONTROL HEAT;PGF PRODUCT;             27 MAY 92;RECHECK ON;20 JUN 92;;
  29 FEB 92;AI;;SENATOR;;;;1.00;;                 24 JUN 92;OPEN;;;;;
   7 MAR 92;AI;;SENATOR;;;;1.00;;                 26 JUN 92;AI;;CAESAR;;;;1.00;;
  29 MAR 92;AI;;BROKER;;;;1.00;;                  18 JUL 92;AI;;ONYXAR;;;;1.00;;

VAL                  NVH     CALVED                          56      0  0
   7 JUL 92;CALVED;1;0;1;0;
   7 JUL 92;CALF ID;92-VAL;FEMALE;

--------------------------------------------------------------------------------
NVH      - No visible heat observed      NYMPH   - Nymphomaniac
FTC      - Failure to conceive           NER     - No event recorded
PP       - Postpartum check              RECHK   - Recheck flag on
PD       - Pregnancy diagnosis           OP165   - Open longer than 165 days
PD EARL -  Early reconfirm pregnancy     OVERDUE - Animal overdue
PD LATE -  Late reconfirm pregnancy      PENDO   - Pyometra or endometritis
```

Whole Herd Evaluation
1 SEP 91 - 31 AUG 92
FARM: FARM #6

DairyCHAMP 1.1

Printed: 1 SEP 92

	ARITHMETIC MEAN	GEOMETRIC MEAN	STD DEV	SAMPLE SIZE	MIN	MAX	95 % CONFIDENCE INTERVAL
KEY REPRODUCTIVE INDICES:							
Calving to calving intv (d)	277.00	277.00	0.00	1	277	277	0.00 - 0.00
Calving to first heat intv (d)	84.21	79.52	28.10	19	29	147	66.78 - 94.69
Calving to first serv intv (d)	87.26	84.20	24.85	19	55	147	73.89 - 95.94
Calving to conception intv (d)	91.27	87.64	28.16	11	64	147	71.90 - 106.83
Deferral Days (d)	29.00	28.84	4.24	2	26	32	7.71 - 107.88
CONCEPTION & HEAT DETECTION EFFICIENCY:							
Proport'n conciev at 1st serv	0.82	-	0.12	11	-	-	0.56 - 1.00
Proport'n conciev at 2nd+ serv	0.11		0.07	19	-	-	0.00 - 0.25
Serv / concep for cows conceiv	1.18		0.33	11	1	2	0.45 - 1.91
Proport'n in heat by 60 day	0.11		0.07	19	-	-	0.00 - 0.25
Heat detection rate	67.02		-	-	-	-	- - -
Ratio of 1* to 2* interest int	5.50		-	-	-	-	- - -
Proport'n pregnant at PD	0.80	-	0.09	20	-	-	0.61 - 0.99
MASTITIS & LACTATION RELATED INDICES:							
Lactation length (d)	0.00		0.00	0	0	0	0.00 - 0.00
Days dry (d)	0.00		0.00	0	0	0	0.00 - 0.00
Qtr infect'n prevalence at DO	0.00		0.00	0	-	-	0.00 - 0.00
Qtr affected/clinical mastitis	0.67		0.47	3	1	1	0.00 - 2.70
Proport'n of clinical mastitis	0.09	-	0.05	35	0	1	0.00 - 0.19
DISEASE INCIDENCE:							
Abortion	0.09	-	0.05	35	-	-	0.00 - 0.18
Dystocia	0.00	-	0.00	35	-	-	0.00 - 0.00
Metritis	0.00	-	0.00	35	-	-	0.00 - 0.00
Luteal cyst	0.00	-	0.00	35	-	-	0.00 - 0.00
Follicular cyst	0.00	-	0.00	35	-	-	0.00 - 0.00
Retained placenta	0.0[illegible]	-	0.03	35	-	-	0.00 - 0.09
Ketosis	0.00	-	0.00	35	-	-	0.00 - 0.00
Milk fever	0.03	-	0.03	35	-	-	0.00 - 0.09
Hardware disease	0.00	-	0.00	35	-	-	0.00 - 0.00
Feet & leg problems	0.00	-	0.00	35	0	0	0.00 - 0.00
Parasitic diseases	0.00	-	0.00	35	-	-	0.00 - 0.00
Bloat	0.00	-	0.00	35	0	0	0.00 - 0.00
Abomasal displacemen	0.00	-	0.00	35	-	-	0.00 - 0.00
MILK PRODUCTION:							
Ave milk weight to date	4329.87	3154.82	2640.27	32	230	9273	2209 - 4506

	ARITHMETIC MEAN	GEOMETRIC MEAN	STD DEV	SAMPLE SIZE	MIN	MAX	95 % CONFIDENCE INTERVAL
REMOVED COWS:							
Proport'n ended with removed	0.14	-	0.06	35	-	-	0.02 - 0.26
Ave days in milk when removed	82.80	27.32	105.65	5	4	238	2.74 - 271.91
Prop'n: Reprod reasons	0.00	-	0.00	5	0	0	0.00 - 0.00
Prop'n: Mastitis	0.20	-	0.20	5	0	1	0.00 - 0.76
Prop'n: Udder health	0.00	-	0.00	5	0	0	0.00 - 0.00
Prop'n: Feet & leg problems	0.00	-	0.00	5	0	0	0.00 - 0.00
Prop'n: Low production	0.00	-	0.00	5	0	0	0.00 - 0.00
Prop'n: Management decisions	0.00	-	0.00	5	0	0	0.00 - 0.00
Prop'n: Undefined	0.00	-	0.00	5	0	0	0.00 - 0.00
Prop'n: Undefined	0.00	-	0.00	5	0	0	0.00 - 0.00
Prop'n: Undefined	0.00	-	0.00	5	0	0	0.00 - 0.00
Prop'n: Undefined	0.00	-	0.00	5	0	0	0.00 - 0.00
Prop'n: other reasons	0.80	-	0.40	5	0	1	0.00 - 1.91
REMOVED HEIFERS:							
Proport'n ended with removed	0.00	-	0.00	20	-	-	0.00 - 0.00
Ave age when removed	0.00	0.00	0.00	0	0	0	0.00 - 0.00
HEIFER PERFORMANCE:							
Age at first breeding (m)	13.42	12.06	8.33	2	8	19	0.03 -4769.65
Age at conception (m)	0.00	0.00	0.00	0	0	0	0.00 - 0.00
Age at calving (m)	39.14	39.14	0.00	1	39	39	0.00 - 0.00
Proport'n conciev at 1st serv	0.00	-	0.00	0	-	-	0.00 - 0.00
Proport'n conciev at 2nd+ serv	0.00	-	0.00	1	-	-	0.00 - 0.00
Serv/conc for heif conceived	0.00	-	0.00	0	0	0	0.00 - 0.00

Remark: 1. Milk weight is measured in kilogram(s)
2. Lactation records processed are as follows:
- 1 completed lactation record(s)
- 1 completed heifer record(s)
- 6 removed lactation record(s)
- 0 removed heifer record(s)
- 28 active lactation record(s)
- 19 active heifer record(s)

PERIODIC: Whole Herd Analysis
1 DEC 91 - 31 AUG 92
FARM: FARM #6

DairyCHAMP 1.1

Printed: 1 SEP 92

	DEC91	JAN92	FEB92	MAR92	APR92	MAY92	JUN92	JUL92	DEC91 JUL92	AUG92
HERD STATUS AT PERIOD END:										
Percent not pregnant milking	58.3	60.0	48.6	54.3	58.8	48.4	51.6	56.7	56.7	56.7
Percent pregnant milking	33.3	34.3	45.7	37.1	35.3	45.2	41.9	43.3	43.3	43.3
Percent pregnant dry	8.3	5.7	5.7	8.6	5.9	6.5	6.5	.	.	.
Percent not pregnant dry	.	.	.	.	.	.	.	.	.	.
Total number of cows	36	35	35	35	34	31	31	30	30	30
HERD DISTRIBUTION:										
Heifers calved	3	1	.	1	2	.	.	.	7	.
Cows calved	1	3	.	4	1	3	.	4	16	2
Cows entered	.	.	.	.	.	.	.	.	.	.
Cows sold	.	.	.	1	2	2	.	.	5	.
Cows died	.	.	.	.	1	1	.	.	2	.
1st lactation cows	17	17	17	16	15	11	11	9	9	8
2nd lactation cows	3	3	3	4	4	6	6	7	7	8
3rd lactation cows	6	5	5	4	4	4	4	4	4	3
4th lactation cows	6	6	6	6	6	6	6	6	6	6
5th lactation cows	2	3	3	3	2	2	2	2	2	3
6th+ lactation cows	2	1	1	2	3	2	2	2	2	2
Ave lactation number	2.3	2.2	2.2	2.3	2.4	2.5	2.5	2.5	2.5	2.5
HERD PRODUCTION SUMMARY:										
Ave milk / cow / day *	22.0	21.0	23.4	22.9	23.4	26.4	28.9	22.5	23.7	22.5
Adjusted corrected milk	.	.	.	.	.	.	.	.	.	.
Lact periods collected	.	1	.	3	1	2	.	.	7	.
Ave lactation length	.	296	.	329	304	346	.	.	325	.
Dry periods collected	1	2	.	2	1	2	.	2	10	.
Ave days dry	56	92	.	110	56	46	.	47	70	.
Ave days in milk	177	177	206	182	192	194	224	207	194	196
% days in milk	88.4	91.0	94.3	92.7	91.3	94.9	93.5	99.5	93.1	100.0
Ave % lactose	.	.	.	.	.	.	.	.	.	.
Ave % fat	.	.	.	.	.	.	.	.	.	.
Ave % solids not fat	.	.	.	.	.	.	.	.	.	.
Ave % protein	.	.	.	.	.	.	.	.	.	.
Ave somatic cell count **	318	376	421	447	388	230	202	360	349	316
Ave genetics cow conceptus	.	.	.	.	.	.	.	.	.	.
Ave genetics heif conceptus	.	.	.	.	.	.	.	.	.	.

---

* Milk weight is measured in kilogram(s)
** Somatic cell count reports in 1,000's

PERIODIC: Whole Herd Analysis
1 DEC 91 - 31 AUG 92
FARM: FARM #6
Page: 2

DairyCHAMP 1.1
Copyright 89 Univ of Minn
Printed: 1 SEP 92

	DEC91	JAN92	FEB92	MAR92	APR92	MAY92	JUN92	JUL92	DEC91 JUL92	AUG92
KEY REPRODUCTIVE INDICES:										
1st heats observed	1	4	1	3	3	1	2	3	18	.
Ave calving to 1st heat (d)	97.0	99.5	129.0	75.0	89.3	90.0	82.5	93.7	91.8	.
1st services	2	4	1	3	3	1	2	3	19	.
Ave calving to 1st serv (d)	93.0	99.5	129.0	75.0	89.3	90.0	82.5	93.7	91.7	.
Cows diagnosed pregnant	1	2	4	2	1	4		1	15	2
Ave calving to concept'n (d)	108.0	173.5	95.8	102.0	67.0	186.0	.	90.0	129.5	105.5
Heats deferred	1	.	.	.	.	.	.	.	1	.
Deferral days	32.0	.	.	.	.	.	.	.	32.0	.
Cows open at end period	21	21	17	19	20	15	16	17	17	17
Ave days open for open cows	128.9	120.2	142.2	126.9	143.6	129.4	165.1	130.5	130.5	131.9
Cows open > 120 days	9	10	8	6	9	6	9	9	9	8
percent cows open > 120 days	26.2	29.2	22.9	16.7	26.1	18.7	29.0	29.3	29.3	26.7
CONCEPTION EFFICIENCY:										
1st services diag preg	1	3	.	2	1	1	1	1	10	.
1st serv concept'n rate (%)	50.0	75.0	.	66.7	33.3	100.0	50.0	33.3	52.6	.
2nd+ services	2	2	2	3	3	2	4	3	21	4
2nd+ services diag preg	1	1	.	.	2	.	.	.	4	.
2nd+ serv concept'n rate (%)	50.0	50.0	.	.	66.7	.	.	.	19.0	.
Overall conception rate (%)	50.0	66.7	.	33.3	50.0	33.3	16.7	16.7	35.0	.
Ave Servs/con for cows bred	2.0	1.5	.	3.0	2.0	3.0	6.0	6.0	2.9	.
Ave Servs/con for cows conceiv	2.0	2.5	1.5	1.0	1.0	2.3	.	1.0	1.7	1.0
HEAT DETECTION EFFICIENCY:										
Cows calved & reached 60 day	2	2	4	4	2	4	2	3	23	2
Percent in heat by 60 days	.	.	.	.	.	.	.	.	.	.
Heat intervals obtained	4	3	4	3	3	2	4	3	26	6
Heat detection rate	49.4	58.3	87.5	42.9	29.7	46.7	66.1	86.3	53.4	64.3
Ratio of 1*-2* interestrus	.	.	.	.	.	.	.	.	13.0	1.0
Pregnancy exams	3	5	10	2	6	5	4	5	40	3
Percent cows pregnant at PD	33.3	80.0	80.0	100.0	50.0	100.0	50.0	60.0	70.0	100.0
ABORTION:										
Abortions	.	.	.	1	.	.	.	.	1	1
Abortion rate (annual)	.	.	.	32.8	.	.	.	.	4.5	39.2
Aborted in 1st trimest	.	.	.	.	.	.	.	.	.	.
Aborted in 2nd trimest	.	.	.	1	.	.	.	.	1	.
Aborted in 3rd trimest	.	.	.	.	.	.	.	.	.	1
Unknown gest length	.	.	.	.	.	.	.	.	.	.
Ave gest len of aborted cows	.	.	.	187.0	.	.	.	.	187.0	203.0
Ave lact num of aborted cows	.	.	.	4.0	.	.	.	.	4.0	1.0

PERIODIC: Whole Herd Analysis
1 DEC 91 - 31 AUG 92
FARM: FARM #6
Page: 3

DairyCHAMP 1.1
Copyright 89 Univ of Minn
Printed: 1 SEP 92

	DEC91	JAN92	FEB92	MAR92	APR92	MAY92	JUN92	JUL92	DEC91 JUL92	AUG92
HEIFER PERFORMANCE:										
Heifers aged over 365 days	19.6	18.0	18.7	18.6	17.6	16.3	16.0	16.0	17.6	16.0
First bred heifers	6	2	2	2	.	2	.	3	17	1
Ave age at 1st breeding (m)	17.7	19.9	17.2	.	.	13.7	.	18.2	17.5	17.8
Heifers confirmed pregnant	.	2	3	.	2	.	.	1	8	.
Ave age at conception (m)	.	16.6	19.3	.	17.2	.	.	19.9	18.2	.
Heifers calved	3	1	.	1	2	.	.	.	7	.
Ave age of heifers calv (m)	27.4	25.2	.	25.6	33.6	.	.	.	28.6	.
1st services diag pregnant	3	1	2	.	.	1	.	.	7	.
1st serv concept'n rate (%)	50.0	50.0	100.0	.	.	50.0	.	.	41.2	.
2nd+ services in period	1	1	2	1	.	.	.	.	5	2
2nd+ services diag pregnant	1	.	.	.	.	.	.	.	1	.
2nd+ serv concept'n rate (%)	100.0	.	.	.	.	.	.	.	20.0	.
Service/con for heif conceiv	.	1.5	1.0	.	1.0	.	.	1.0	1.1	.
Heifers sold or transferred	.	.	.	.	.	1	.	.	1	.
Heifers died or destroyed	.	.	.	.	.	.	.	.	.	.
CALF REARING:										
Calves born in period	4	5	.	5	3	3	.	4	24	2
Calves born dead	1	.	.	.	.	.	.	.	1	.
Calves sold or transferred	.	.	.	.	.	.	.	.	.	.
Calves born and raised	1	4	.	3	1	2	.	3	14	2
Number died (birth-29 days)	.	.	.	.	.	.	.	.	.	.
Crude death rate	.	.	.	.	.	.	.	.	.	.
Number died (30-365 days)	.	.	.	.	.	.	.	.	.	.
Crude death rate	.	.	.	.	.	.	.	.	.	.
# died: Enteritis	.	.	.	.	.	.	.	.	.	.
# died: Pneumonia	.	.	.	.	.	.	.	.	.	.
# died: Septicaemia	.	.	.	.	.	.	.	.	.	.
CULLING SUMMARY:										
Ave milking herd	34.3	34.3	35.0	35.9	34.4	32.2	31.0	30.7	33.5	30.0
Cows culled	.	.	.	1	3	3	.	.	7	.
Overall culling rate(annual)	.	.	.	32.8	106.0	109.8	.	.	31.3	.
Ave lact num of cull cows	.	.	.	2.0	1.0	3.0	.	.	2.0	.
Culled: Reprod reasons	.	.	.	.	.	.	.	.	.	.
Culled: Mastitis	.	.	.	.	.	1	.	.	1	.
Culled: Udder health	.	.	.	.	.	.	.	.	.	.
Culled: Feet & leg problems	.	.	.	.	.	.	.	.	.	.
Culled: Low production	.	.	.	.	.	.	.	.	.	.
Culled: Management decisions	.	.	.	.	.	.	.	.	.	.
Culled: Undefined	.	.	.	.	.	.	.	.	.	.
Culled: Undefined	.	.	.	.	.	.	.	.	.	.
Culled: Undefined	.	.	.	.	.	.	.	.	.	.
Culled: Undefined	.	.	.	.	.	.	.	.	.	.

PERIODIC: Whole Herd Analysis
1 DEC 91 - 31 AUG 92
FARM: FARM #6
Page: 4

DairyCHAMP [illegible]
Copyright 89 Univ of Minn
Printed: [illegible] SEP 92

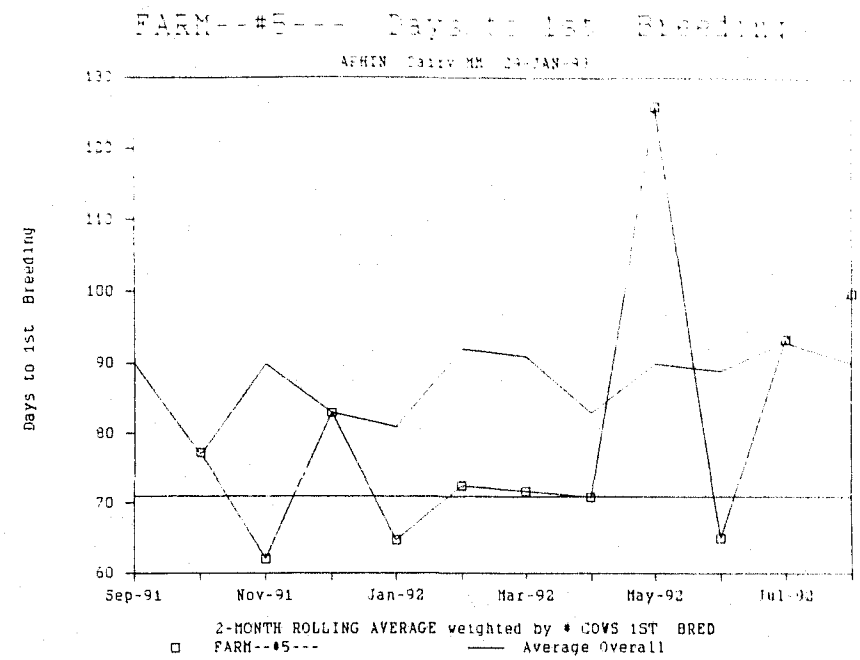
	DEC91	JAN92	FEB92	MAR92	APR92	MAY92	JUN92	JUL92	DEC91 JUL92	AUG92
DISEASE SUMMARY:										
Ave milking herd size	34.3	34.3	35.0	35.9	34.4	32.2	31.[illegible]	30.[illegible]	33.5	30.[illegible]
Cows calved the period	4	4	.	5	3	3	.	4	23	2
Dystocia	.	.	.	.	.	.	.	.	.	.
Metritis	.	.	.	.	.	.	.	.	.	.
Luteal cyst	.	.	.	.	.	.	.	.	.	.
Follicular cyst	.	.	.	.	.	.	.	.	.	.
Retained placenta	1	.	.	.	.	.	.	.	1	.
Ketosis	.	.	.	.	.	.	.	.	.	.
Milk fever	.	.	.	.	.	1	.	.	1	.
Hardware disease	.	.	.	.	.	.	.	.	.	.
Feet & leg problems	.	.	.	.	.	.	.	.	.	.
Parasitic diseases	.	.	.	.	.	.	.	.	.	.
Bloat	.	.	.	.	.	.	.	.	.	.
Abomasal displacemen	.	.	.	.	.	.	.	.	.	.
Undefined	.	.	.	.	.	.	.	.	.	.
CLINICAL MASTITIS INDICES:										
Cow cases in the period	.	.	.	1	.	2	.	.	3	.
Cow cases/100 cows/30 days	.	.	.	2.7	.	6.0	.	.	1.1	.
Quarters (qtr) affected	.	.	.	1	.	1	.	.	2	.
Ave qtrs affected per cow	.	.	.	1.0	.	0.5	.	.	0.7	.
Repeated cow cases	.	.	.	.	.	.	.	.	.	.
SUMMARY FOR QTR SAMPLES AT DRY OFF:										
Quarter samples taken at DO	.	.	.	.	.	.	.	.	.	.
Qtrs SCC > 280000,CMT > Trac	.	.	.	.	.	.	.	.	.	.
Qtr infectn prevalence at DO	.	.	.	.	.	.	.	.	.	.
Qtrs positive cultures	.	.	.	.	.	.	.	.	.	.
Qtrs positive staphylococ	.	.	.	.	.	.	.	.	.	.
Qtrs positive streptococc	.	.	.	.	.	.	.	.	.	.
Qtrs positive coliform	.	.	.	.	.	.	.	.	.	.
Qtrs positive mixed infec	.	.	.	.	.	.	.	.	.	.
Qtrs positive others	.	.	.	.	.	.	.	.	.	.
SUMMARY FOR QTR SAMPLES DURING LACTATION:										
Quarter samples during lact	.	.	.	.	.	.	.	.	.	.
Qtrs SCC > 280000,CMT > Trac	.	.	.	.	.	.	.	.	.	.
Qtrs positive cultures	.	.	.	.	.	.	.	.	.	.
Qtrs positive staphylococ	.	.	.	.	.	.	.	.	.	.
Qtrs positive streptococc	.	.	.	.	.	.	.	.	.	.
Qtrs positive coliform	.	.	.	.	.	.	.	.	.	.
Qtrs positive mixed infec	.	.	.	.	.	.	.	.	.	.
Qtrs positive others	.	.	.	.	.	.	.	.	.	.

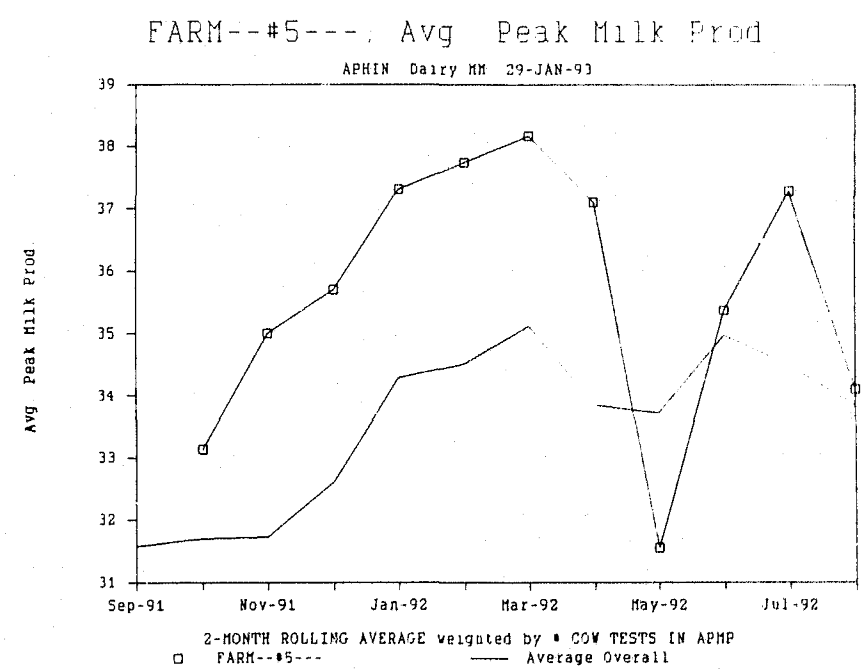
APPENDIX D: APHIN Reports

Dairy herd health and production parameters currently being monitored by APHIN and available for graphical presentation include:

1) Average milk production: the average test-day milk weight (kg) for all cows tested during the month.
2) Peak milk production: the average milk production (kg/day) of cows in their second or greater lactation and between 40 and 70 days fresh (post calving).
3) Adjusted-corrected-milk: a measure of average milk production that has been adjusted for the average stage of lactation in the herd, the herd butterfat level and the proportion of the herd that is in first lactation. The calculation utilizes data from two sources (ADLIC and Milk Quality Laboratory) and does not necessarily have the same seasonal (summer) decline as does average milk production.
4) Butterfat: the average (g/l) of the Milk Quality Laboratory measurements of the bulk-tank butterfat level made during the month.
5) Bulk tank somatic cell count (SCC): the average of the Milk Quality Laboratory measurement of the bulk-tank SCC ($X10^3$ cells/ml) made during the month.
6) Plate loop: the average of the Milk Quality Laboratory measurement of the bulk-tank plate loop count ($X10^3$ cells/ml) made during the month. Only actual counts between 30000 and 300000 are reported; values outside that range are entered as the end points of the range (ie 30 and 300).
7) Proportion of cows over 200000 cells/ml: the proportion of cows in the herd with individual-cow SCC greater than 200000 cells/ml on the ADLIC test day.
8) Incidence of clinical mastitis: this is the number of cases of clinical mastitis per 100 cows milking during the month. The reliability of these data is believed to vary from farm to farm.
9) Days to first service: the average number of days from calving to the first service, for all cows receiving their first service during the month.
10) Days to conception: the average number of days from calving to the last breeding of cows which were confirmed pregnant during the month.
11) Proportion confirmed in calf by 150 days: the proportion of cows which reached 150 days post-partum during the month and which were confirmed pregnant on or before that 150th day.
12) Age at conception - heifers: the average age of heifers at the time of their last breeding, for heifers confirmed pregnant during the month.

Example of the graphs available from APHIN.





APPENDIX E: Database as a Regional and National Tool

Sample questions submitted by Agriculture Canada.

a) At any given time, what proportion of dairy herds have at least one cow on anti-microbial therapy, such that their milk should not be included in the tank?

b) At any given time, what proportion of dairy cows are on antimicrobial therapy, such that their milk should not be included in the tank?

Attempts were made to answer these questions using the HERD database. Data were available for the number of cows milking each month and the number of cows treated for various diseases each month. Assumptions were made as to which of these diseases would be treated with antibiotics. Relevant summary herd data were extracted and imported into a spreadsheet program (Lotus 123) for further analysis. For each cow treated the milk will be unfit for some days during and after treatment.

The probability of a cow having unfit milk = P_c

$$P_c = \frac{\text{(monthly average number treated X days unfit per cow treated)}}{\text{(monthly average number milking X 30.4 days per month)}}$$

The probability of a cow not having unfit milk = $1 - P_C$
The probability of a herd not having a cow with unfit milk = $(1 - P_C)^{\#milking}$

The probability of a herd having 1 or more cows with unfit milk = P_h

$$P_h = 1 - (1 - P_c)^{\#\text{ milking}}$$

The formula were modeled in the spreadsheet to examine these probabilities for an average herd, assuming a given number of days that milk is unfit after treatment of a cow with antibiotics.

Assuming the milk is unfit for 5 days per treatment, in our study group:

a) At any given time, 20% of dairy herds have at least one cow on anti-microbial therapy, such that their milk should not be included in the tank.

b) At any given time, 1% of dairy cows are on antimicrobial therapy, such that their milk should not be included in the tank.

Ave days milk is unfit: 5

	Average milking	Average treated	P(cow)	P(herd)
1	13.17	3.50	0.04	0.44
2	24.00	1.25	0.01	0.19
3	24.92	0.33	0.00	0.05
4	34.08	0.17	0.00	0.03
5	28.75	1.83	0.01	0.26
6	29.67	0.33	0.00	0.05
7	23.67	0.08	0.00	0.01
8	28.00	1.08	0.01	0.16
9	35.42	1.17	0.01	0.18
10	16.33	2.42	0.02	0.33
11	61.67	0.33	0.00	0.05
12	25.17	3.50	0.02	0.44
			P(cow)	***P(herd)***
Ave Herd	28.74	1.33	**0.01**	**0.20**

If we assume milk is unfit for 10 days per treatment, these proportions go to 36% of herds and 2% of cows.

Ave days milk is unfit: 10

	Average milking	Average treated	P(cow)	P(herd)
1	13.17	3.50	0.09	0.70
2	24.00	1.25	0.02	0.34
3	24.92	0.33	0.00	0.10
4	34.08	0.17	0.00	0.05
5	28.75	1.83	0.02	0.46
6	29.67	0.33	0.00	0.10
7	23.67	0.08	0.00	0.03
8	28.00	1.08	0.01	0.30
9	35.42	1.17	0.01	0.32
10	16.33	2.42	0.05	0.56
11	61.67	0.33	0.00	0.10
12	25.17	3.50	0.05	0.69
			P(cow)	***P(herd)***
Ave Herd	28.74	1.33	**0.02**	**0.36**

APPENDIX F: Additional Standard Plate Counts

Analysis of Standard Plate Count data for replicate testing of fresh bulk tank milk samples and testing after bulk tank milk samples had been stored in a commercial freezer.

STATISTIX 4.0

Variability of the Standard Plate Count with three replicate plates.

ONE-WAY AOV FOR: LOGD1 LOGD2 LOGD3

SOURCE	DF	SS	MS	F	P
BETWEEN	2	0.04513	0.02256	0.67	0.5187
WITHIN	327	11.0626	0.03383		
TOTAL	329	11.1078			

	CHI-SQ	DF	P
BARTLETT'S TEST OF EQUAL VARIANCES	17.17	2	0.0002

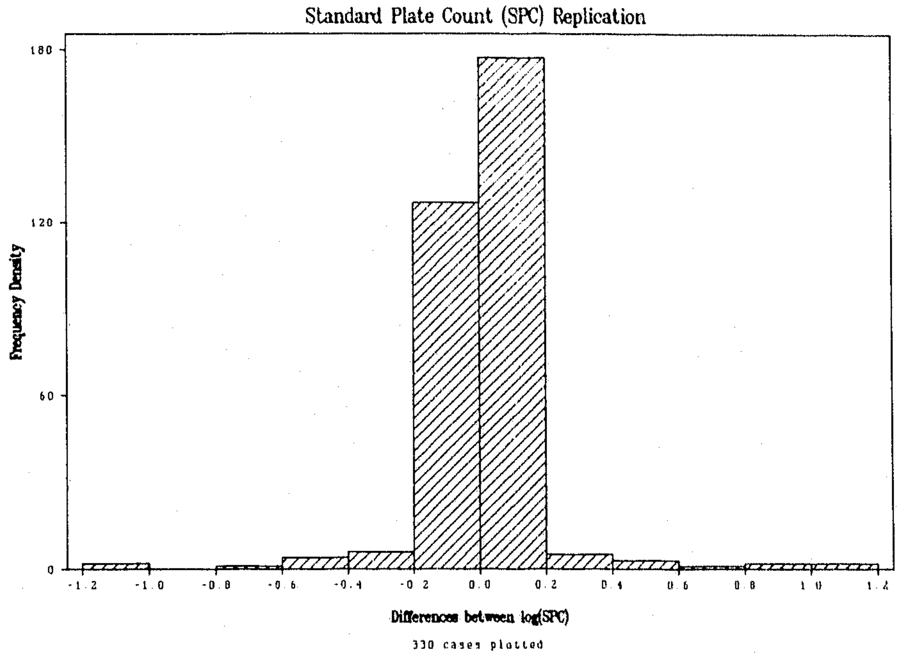
COCHRAN'S Q 0.4339
LARGEST VAR / SMALLEST VAR 2.1921

COMPONENT OF VARIANCE FOR BETWEEN GROUPS -1.024E-04
EFFECTIVE CELL SIZE 110.0

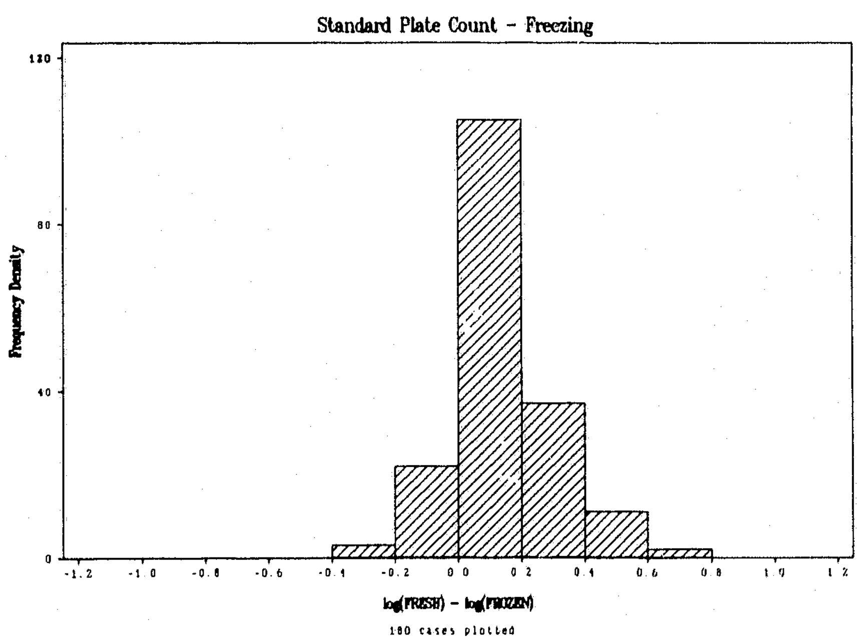
VARIABLE	MEAN	SAMPLE SIZE	GROUP STD DEV
LOGD1	-5.187E-03	110	0.1417
LOGD2	0.0166	110	0.2098
LOGD3	0.0218	110	0.1933
TOTAL	0.0110	330	0.1839

CASES INCLUDED 330 MISSING CASES 270

Distribution of the difference observed between the log of the Standard Plate Count when three replications were done on one milk sample.



Distribution of the difference observed between the log of the Standard Plate Count for fresh milk sample and repeated after the sample was stored in a commercial freezer.



Predictability of fresh sample standard plate count from frozen sample count was examined by linear regression.

STATISTIX 4.0

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF log(FRESH)

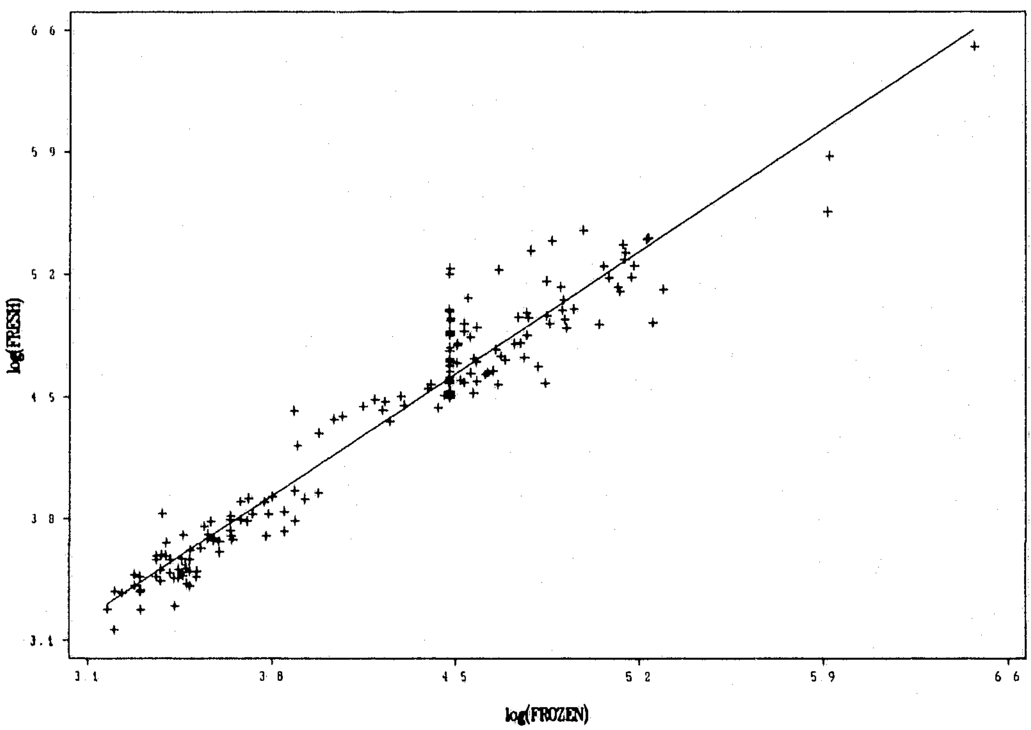
PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P	VIF
CONSTANT	0.24121	0.08538	2.82	0.0053	
LOGFROZEN	0.95977	0.02116	45.35	0.0000	1.2
DAYS	0.00132	3.076E-04	4.30	0.0000	1.2

R-SQUARED	0.9392	RESID. MEAN SQUARE (MSE)	0.02656
ADJUSTED R-SQUARED	0.9385	STANDARD DEVIATION	0.16299

SOURCE	DF	SS	MS	F	P
REGRESSION	2	72.5889	36.2944	1366.10	0.0000
RESIDUAL	177	4.70251	0.02656		
TOTAL	179	77.2914			

CASES INCLUDED 180 MISSING CASES 0

Scatter Plot of LOGAVEFRE vs LOGFROZEN

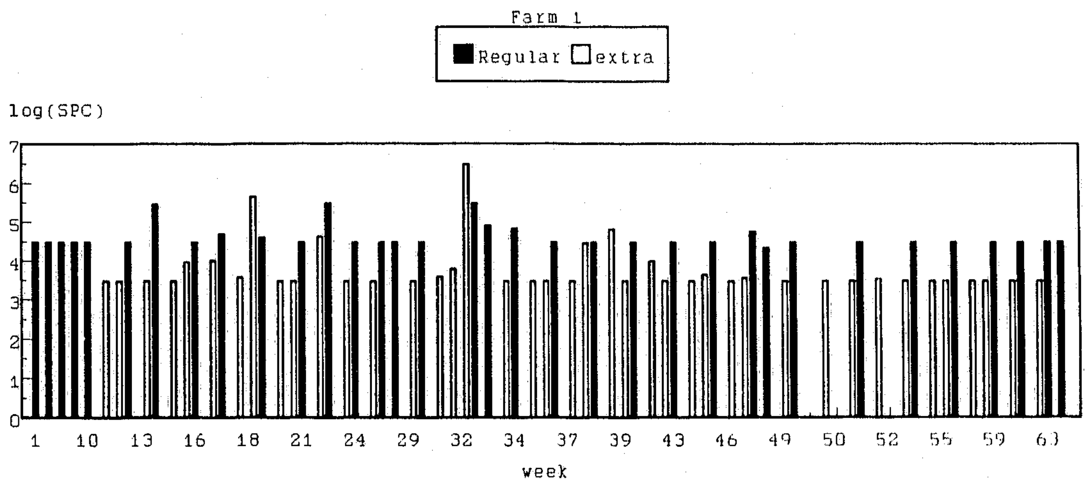


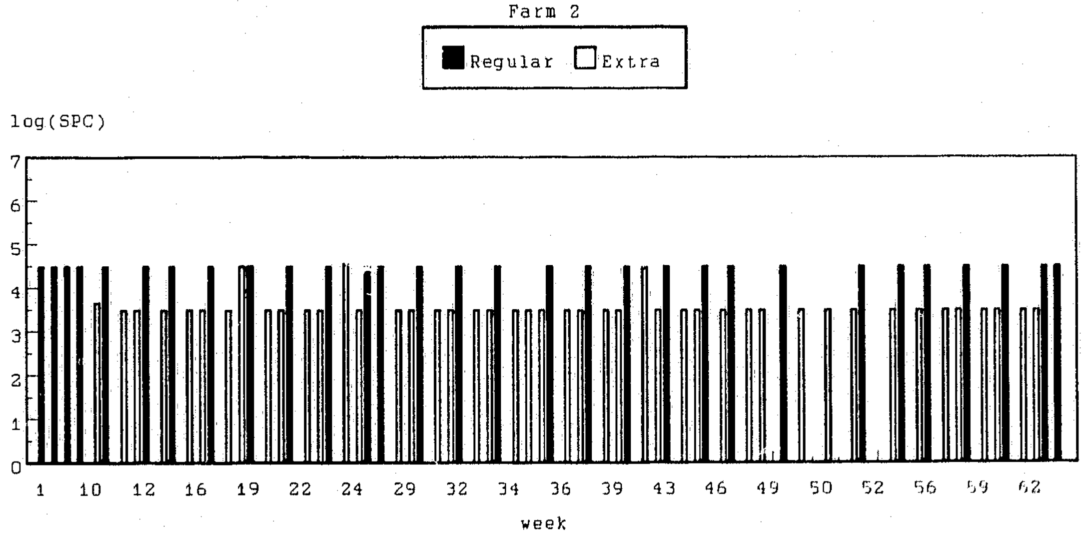
WEEKLY STANDARD PLATE COUNT (SPC)

Regular twice monthly SPC (cells/ml) were reported by the Provincial Dairy Laboratory as the actual count if between 30,000 ($\log_{10}$=4.48) and 300,000 ($\log_{10}$=5.48) or reported as <30,000 or >300,000. The <30,000 and >300,000 are depicted as 30,000 and 300,000 respectively (i.e. the hight of the solid columns range from 4.48 to 5.48).

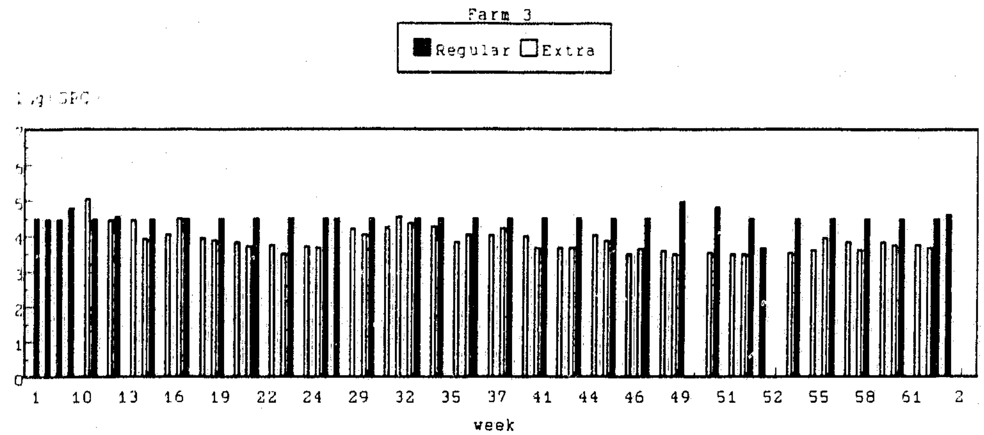
compared to

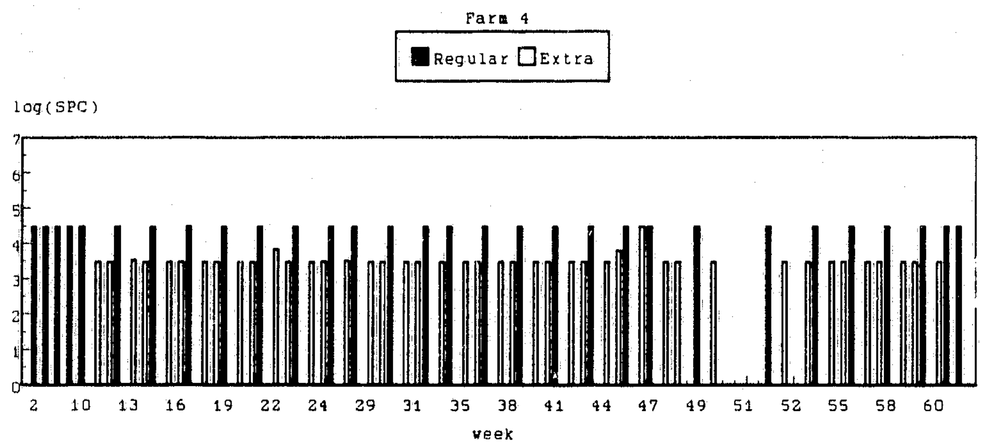
the additional weekly SPC were reported as the actual count if between 3,000 ($\log_{10}$=3.48) and 3,000,000 ($\log_{10}$=6.48) or reported as <3,000 or >3,000,000. The <3,000 and >3,000,000 are depicted as 3,000 and 3,000,000 respectively (i.e. the hight of the outlined columns range from 3.48 to 6.48.

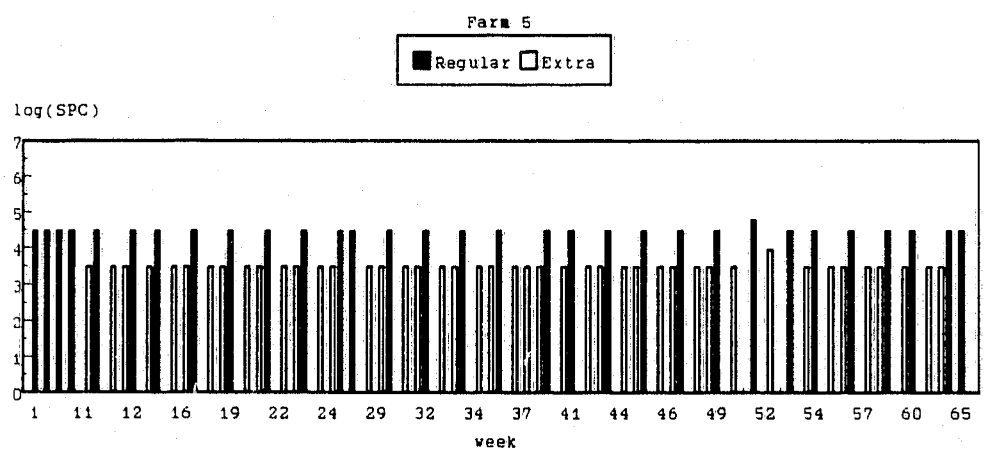




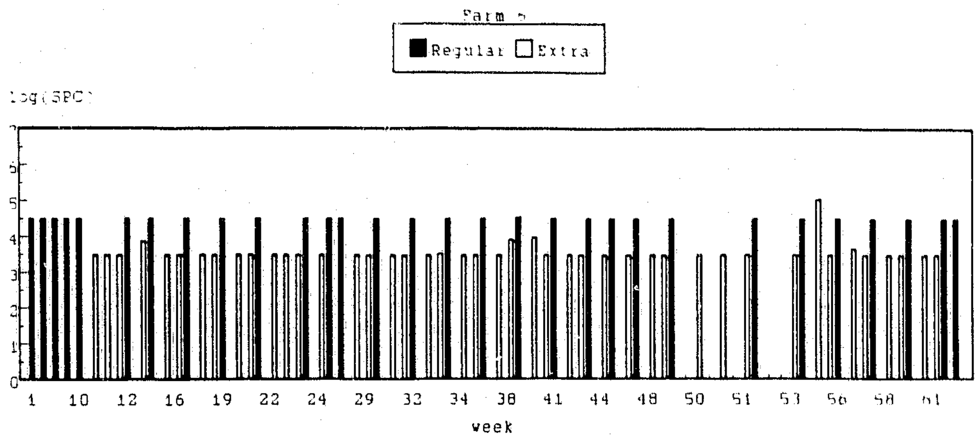
STANDARD PLATE COUNT

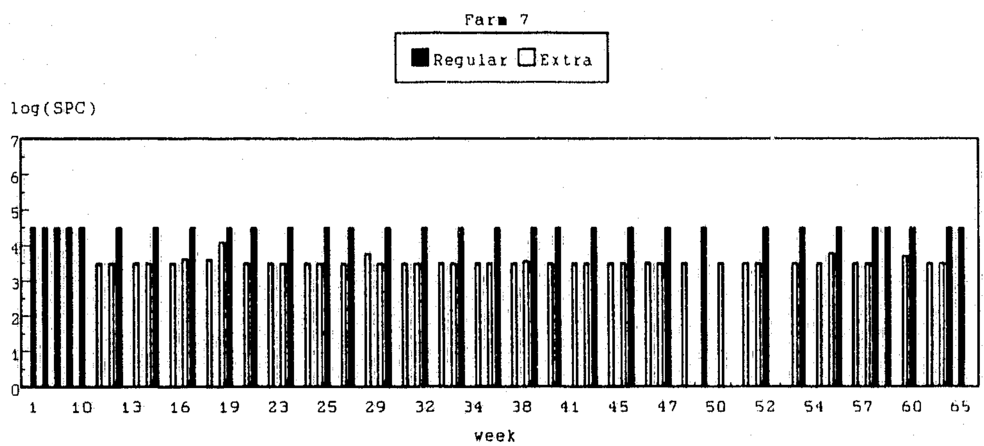


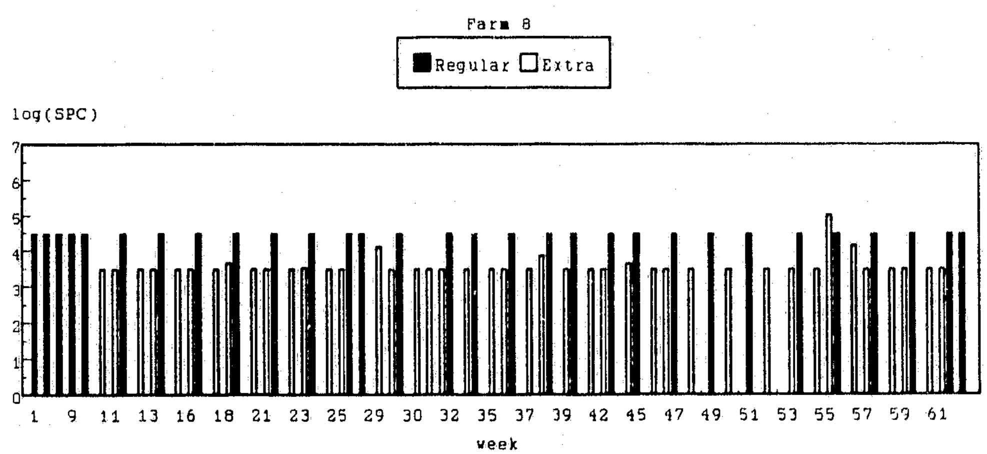




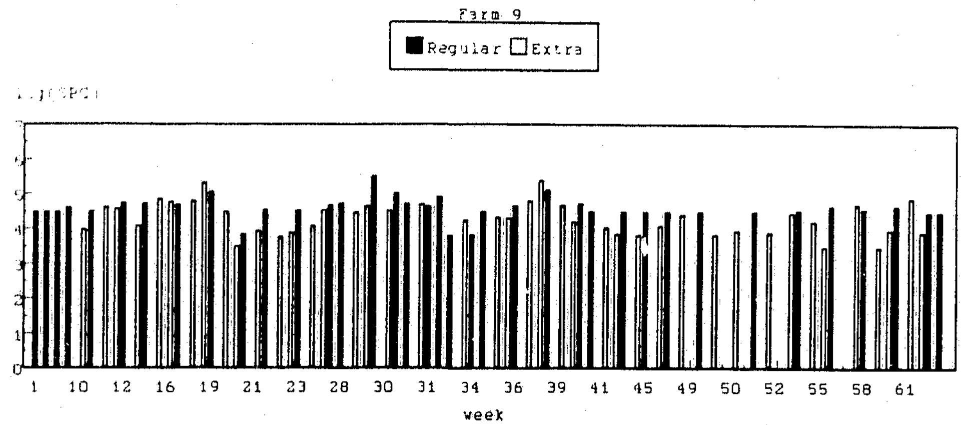
STANDARD PLATE COUNT

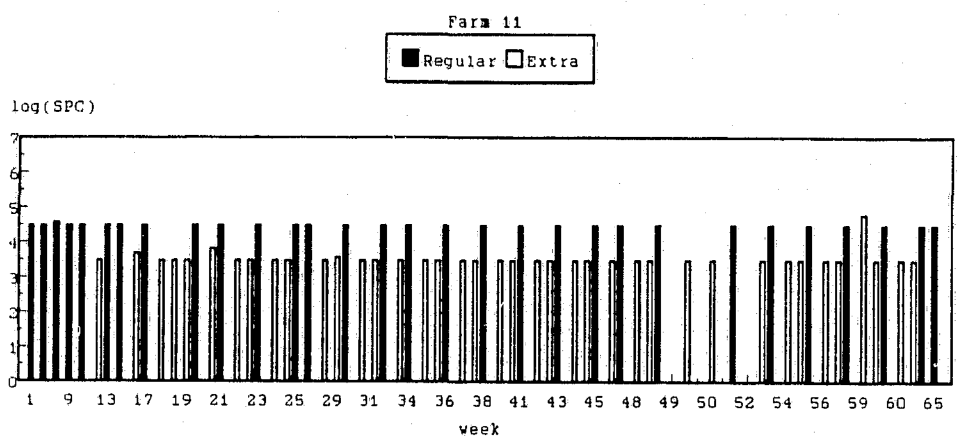


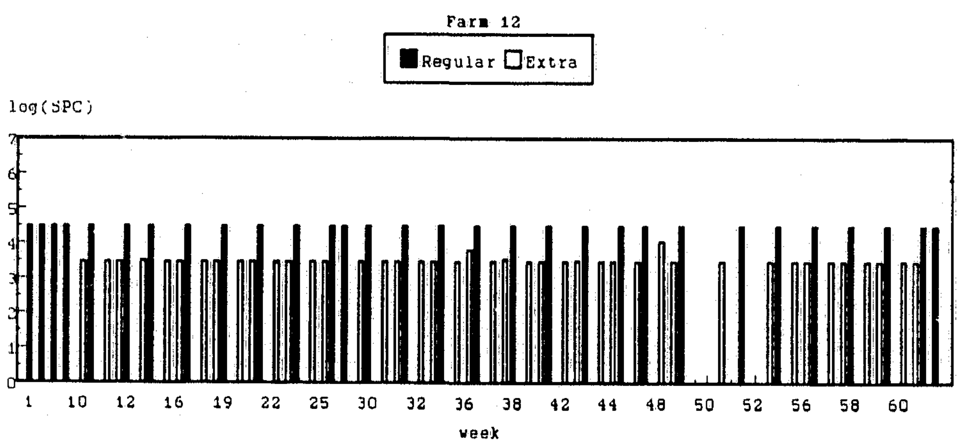




STANDARD PLATE COUNT







APPENDIX G: Dairy Farms Facility and Sanitation Scoring Guidelines

GUIDELINES FOR DAIRY FARM SERVICE REPORT

Facilities

General:

Front Yard	-	Yard surface with good drainage, free from water and mud holes. Deduct 1/2 point unless the yard is cement, pavement or crushed rock maintained in good repair.
Buildings	-	(Housing dairy cattle only) Full points require adequate buildings in number or size with essential facilities for the dairy operation, well painted or steel walls and in good repair. (5 points for size and structure

Milkhouse

Size	-	Full points require: 2 feet between any wall and bulk tank 2 feet between outlet and wall more than 3 feet between wash sink and tank (if tank outlet is less than 2 ft. from floor drain deduct 1 point)
Walls & Ceilings	-	Well insulated, impervious material, tight fitting, painted and in good repair.
Floors	-	Concrete floor in good repair, smooth, free from cracks with good slope to the drain.
Drains	-	Approved trapped drain, covered, sink drain to be connected to the floor drain. Deduct - 1/2 point if drain is not covered - 1/2 point if sink is piped to floor - 1 point if sink is not piped - 2 points if drain is not trapped (if drain is not working deduct all the points)
Lights	-	(2) Electric lights, adequate for washing bulk tank equipment. Full points requires light location so as to avoid broken light bulbs or tubes from entering tank.
Ventilation	-	(2 points) free from excess moisture and odour.
Openings	-	Screened, doors closed in winter - all openings must be tight fitting and screened when left open. Door entering stable must be self-closing.
Hoseport	-	(1 1/2 points) self closing in good repair, tight fitting. (Full points only if manufactured or home made hoseport is in good repair and tight fitting.

Concrete Slab	-	(1 1/2 points) under the exterior of the hoseport, capable of keeping tank truck hose from getting dirty.

Milk Storage and Washing Facilities

Bulk Tank - Proper size, adequate cooling facilities, adjustable legs and in good repair. Hold 6 milkings. (Fluid shipper holding capacity 4 milkings).

Thermometer - Functional and accurate to within 1 degree C or 2 degrees F. (if thermometer is not accurate no points are given).

Milk Cooled to Proper Temperature

- Temperature to be between (1 degree to 4 degrees C) (33 degrees and 40 degrees F) at all times after one hour of milking. To be cooled to below 40 degrees F within one hour after milking and at no time to be above 50 degrees F or 10 degrees C. (to be cooled to 40 degrees F or below one hour after milking and at time of pickup).

Hot and Cold Water Under Pressure

- A sufficient amount of hot and cold running water. Hot water tank capable of supplying a sufficient amount of hot water for rinsing and washing of all the milking equipment and other milkhouse chores at the required temperature.

Adequate Sink Facilities

- (4 points) (Manual cleaning) - 2 compartment dairy sinks in good condition, equipped with mixing taps capable of supplying water to both sinks at the required temperature. (C.I.P. Cleaning) - one compartment sink. (3 points) A second utility sink with mixing taps. (1 point)

Water hose - Hook up separate from sinks. Hose in good condition, equipped with spray nozzle and hung on rack.

Condition of Milk Equipment & Brushes

- All surfaces that come in contact with milk, if metal, to be of stainless steel, smooth, free of open seams and in good condition. Plastic and rubber parts to be in good condition, free of cracks, open seams and smooth. The required brushes to be available in good repair and properly stored.

Storage Racks - Non-corrodible and non-porous storage racks must be provided for the utensil drainage and storing of equipment in the milk house. (good metal racks for full points)

Milking Area

Stable - Floors-concrete, smooth, sufficient size, good condition, in good repair with good drainage (interior).

Stands	-	(2) Stands to be adequate in width and length, smooth surface, impervious and good drainage.
Gutters	-	(2) Adequate in width and depth to hold manure accumulation between cleanings and in good repair.
Mangers,pens	-	(2) Alley-ways, water bowls, etc. - to be adequate and accessible for easy cleaning.
Walls, ceilings-		(3 points each) Smooth surface, free from open seams.
Lighting	-	(3 points) Adequate electric lighting is required.
Ventilation	-	(3 points) Adequate ventilation to maintain stable free of condensation and strong odour. Full points require controlled ventilation with proper air inlets.
Cowyard	-	Surface well drained, capable of maintaining hard footing, located so cattle do not disturb manure storage.

<u>Milking Parlour</u>

Floors	-	Concrete, good drainage, easily cleaned and in good repair.
Walls,ceiling	-	Well insulated, impervious material, well painted, tight fitting and in good repair.
Drains	-	(pit and stand) - Adequate drainage system for stands and pit. To be easily cleaned and properly covered if necessary.
Lighting	-	(2 points) - Adequate electric lighting is required.
Ventilation	-	(2 points) - Parlour to be free of odour and condensation.
Hose and Sufficient Pressure	-	Water hose connected to the water supply in the parlour capable of supplying water with sufficient pressure for cleaning parlour walls and floor after each milking. Hose to be stored on a wall rack in clean condition when not in use. Deduct 1/2 point if no wall rack for hose.

<u>Free Stall Area</u>

Floors	-	Impervious, free from cracks and in good repair.
Drainage (Interior)	-	Good drainage.
Yard	-	Hard surface, adequate in size, well drained, easily cleaned (in winter the feeding and loafing area).
Ventilation	-	Capable of maintaining the area free of excess moisture and odour.
Free stalls	-	Adequate in number (at least 90% stall/cow ratio). Well constructed and maintained in good repair.

SANITATION

General:

Surroundings - Appearance attractive, well kept, free of accumulation of debris, machinery, junk, weeks, open milkhouse drain, etc.

Manure Removal and Fly Control - Properly managed (removed once/year), area hard surface, dry, located so that odours do not enter Dairy Barn or Milkroom. Absence of flies in summer. Fly control program is required in milkhouse and dairy barn during fly season.

Milkhouse - Floors and drains clean and sanitary. Milkhouse neat and tidy, free of tools, supplies, equipment, furnace, refrigerators, desks, etc. (If furnace cannot be removed it must be partitioned off in milkhouse). (Waste paper receptacle and paper towels are required in milkroom).

Cleanliness of cattle - include cattle milking and not milking.

GUIDELINES FOR SCORING SANITATION

90 - 100%	Excellent -	Items found exceptionally clean
80 - 90%	Very Good-	Items in general found exceptionally clean, however, comments where some improvement could be made.
70 - 80%	Good -	Items basically clean, however, slight trace of milkstone, protein, or other foreign matter present.
60 - 70%	Fair -	Trace of milkstone, room for improvement evident.
50 - 60%	Poor -	Milkstone, protein, inflations rough, improvement required.
0 - 50%	Very Poor -	Equipment is dirty, obvious equipment is not receiving a thorough cleaning after each use.

APPENDIX H: Prediction Models

Model 1: Prediction of average annual bulk-tank somatic cell count using regression analysis for dairy farm inspection scores of facilities and sanitation.

Predictor	Coefficient	S.E.	p-value
INTERCEPT	10.534	0.699	0.000
Main Effects			
SGEN	-0.089	0.017	0.000
SCATTLE	-0.098	0.028	0.001
SMHOUSE	-0.190	0.044	0.000
SEQUIP	-0.017	0.004	0.000
SBARN	-0.020	0.015	0.188
Possible Confounders			
ADL	-0.060	0.046	0.195
INDUST	0.027	0.066	0.686
inspector			0.004
#1	0.079	0.052	0.130
#2	0.143	0.056	0.012
#3	-0.031	0.049	0.526
#4	0.000		
housing			0.196
HCHAIN	-0.066	0.044	0.135
HFREE	0.057	0.058	0.332
HLOOSE	0.144	0.172	0.404
HSTANCH	0.000		
month			0.088
M1	-0.216	0.101	0.032
M2	-0.079	0.102	0.440
M3	-0.263	0.104	0.012
M4	-0.185	0.098	0.058
M5	-0.096	0.097	0.322
M6	-0.099	0.107	0.353
M7	-0.086	0.104	0.408
M8	-0.049	0.103	0.632
M9	-0.183	0.099	0.064
M10	-0.058	0.097	0.551
M11	-0.153	0.102	0.135
M12	0.000		
year	-0.106	0.033	0.001

continued..

Model 1: continued

Interactions			
smhouse*inspector			0.000
SMHOUSE*#1	0.074	0.020	0.000
SMHOUSE*#2	0.102	0.024	0.000
SMHOUSE*#3	0.067	0.022	0.002
SMHOUSE*#4	0.000		
smhouse*month			0.002
SMHOUSE*M1	0.065	0.051	0.201
SMHOUSE*M2	0.134	0.050	0.007
SMHOUSE*M3	0.176	0.051	0.001
SMHOUSE*M4	0.067	0.047	0.151
SMHOUSE*M5	0.140	0.047	0.003
SMHOUSE*M6	0.125	0.048	0.009
SMHOUSE*M7	0.135	0.048	0.005
SMHOUSE*M8	0.105	0.047	0.027
SMHOUSE*M9	0.124	0.046	0.007
SMHOUSE*M10	0.118	0.046	0.010
SMHOUSE*M11	0.177	0.052	0.001
SMHOUSE*M12	0.000		
industrial*seattle			
INDUST*SEATTLE	0.091	0.030	0.002
industrial*year			
INDUST*YEAR	0.084	0.040	0.037
sbarn*industrial			
SBARN*INDUST	0.042	0.013	0.001
sbarn*inspector			0.007
SBARN*#1	-0.028	0.015	0.057
SBARN*#2	-0.060	0.017	0.001
SBARN*#3	-0.036	0.017	0.031
SBARN*#4	0.000		

$R^2 = 0.27$ Adjusted $R^2 = 0.25$ n = 1265

Model 2: Prediction of average 3 month bulk-tank somatic cell count using regression analysis for dairy farm inspection scores of facilities and sanitation.

Predictor	Coefficient	S.E.	p-value
INTERCEP	5.797	0.103	0.000
Main Effects			
SGEN	-0.079	0.019	0.000
SCATTLE	-0.013	0.020	0.522
SMHOUSE	-0.245	0.049	0.000
SEQUIP	-0.015	0.004	0.000
SBARN	-0.018	0.017	0.276
Possible Confounders			
ADL	-0.077	0.048	0.110
INDUST	0.147	0.050	0.004
inspector			0.001
#1	0.105	0.059	0.065
#2	0.182	0.062	0.003
#3	-0.024	0.054	0.661
#4	0.000		
housing			0.115
HCHAIN	-0.087	0.049	0.079
HFREE	0.090	0.070	0.202
HLOOSE	-0.123	0.234	0.560
HSTANCH	0.000		
month			0.001
M1	-0.286	0.111	0.010
M2	-0.288	0.113	0.011
M3	-0.440	0.114	0.000
M4	-0.401	0.107	0.000
M5	-0.284	0.106	0.008
M6	-0.274	0.117	0.020
M7	-0.275	0.114	0.016
M8	-0.170	0.113	0.132
M9	-0.226	0.108	0.038
M10	-0.107	0.106	0.316
M11	-0.129	0.112	0.249
M12	0.000		
year	-0.027	0.025	0.268

continued...

Model 2: continued

Interactions			
scattle*housing			0.011
SCATTLE*HCHAIN	-0.064	0.036	0.077
SCATTLE*HFREE	-0.219	0.082	0.008
SCATTLE*HLOOSE	-0.391	0.342	0.253
SCATTLE*HSTANCH	0.000		
smhouse*inspector			0.000
SMHOUSE*#1	0.074	0.022	0.000
SMHOUSE*#2	0.096	0.026	0.000
SMHOUSE*#3	0.089	0.025	0.000
SMHOUSE*#4	0.000		
smhouse*month			0.001
SMHOUSE*M1	0.102	0.056	0.071
SMHOUSE*M2	0.210	0.055	0.000
SMHOUSE*M3	0.203	0.056	0.000
SMHOUSE*M4	0.113	0.052	0.028
SMHOUSE*M5	0.193	0.052	0.000
SMHOUSE*M6	0.181	0.053	0.000
SMHOUSE*M7	0.186	0.053	0.000
SMHOUSE*M8	0.164	0.052	0.002
SMHOUSE*M9	0.171	0.050	0.000
SMHOUSE*M10	0.168	0.051	0.000
SMHOUSE*M11	0.202	0.058	0.000
SMHOUSE*M12	0.000		
sbarn*inspector			0.030
SBARN*#1	-0.023	0.016	0.148
SBARN*#2	-0.050	0.020	0.009
SBARN*#3	-0.044	0.018	0.017
SBARN*#4	0.000		
sbarn*industrial			
SBARN*INDUST	0.036	0.0140	0.011
sgeneral*scattle			
SGEN*SCATTLE	-0.032	0.011	0.005

$R^2 = 0.24$ Adjusted $R^2 = 0.21$ $n = 1265$

Model 3: Logistic regression model for the prediction of at least one high bulk-tank bacterial count during the year using dairy farm inspection scores of facilities and sanitation.

Predictor	Coefficient	Odds Ratio	p-value
Intercept	1.349		0.175
SEQUIP	-0.064	0.94	0.000
SMHOUSE	0.043	1.04	0.521
SMHOUSE*INDUST	-0.157	0.85	0.029
Industrial	1.292	3.64	0.000
ADL	-0.493	0.61	0.011
Inspector 1	-0.359	0.70	0.089
Inspector 2	-0.332	0.72	0.116
Inspector 3	-0.573	0.56	0.004
Inspector 4	0.000	1.00	
housing free stall	-0.102	0.90	0.698
housing loose	-0.037	0.96	0.959
housing chain tie	0.066	1.07	0.739
housing stanchion	0.000	1.00	
Month 1	-0.003	1.00	0.994
Month 2	-0.057	0.94	0.882
Month 3	-0.677	0.51	0.122
Month 4	-0.094	0.91	0.811
Month 5	-0.275	0.76	0.469
Month 6	-0.130	0.88	0.751
Month 7	0.019	1.02	0.962
Month 8	-0.261	0.77	0.513
Month 9	-0.509	0.60	0.174
Month 10	-0.444	0.64	0.235
Month 11	-0.322	0.72	0.440
Month 12	0.000	1.00	
Year	-0.190	0.83	0.048

[a] Hosmer-Lemeshow goodness-of-fit statistic = 3.44 (p = 0.90)

Model 4: Logistic regression model for the prediction of at least one high bulk-tank bacterial count (during the 3 months around the inspection) using dairy farm inspection scores of facilities and sanitation[a]

Predictor	Coefficient	Odds Ratio	p-value
Intercept	-2.002		0.001
SEQUIP	-0.061	0.94	0.000
SMHOUSE	-0.054	0.95	0.189
Industrial	1.063	2.89	0.000
ADL	-1.046	0.35	0.000
Inspector 1	-0.681	0.51	0.021
Inspector 2	-0.306	0.74	0.262
Inspector 3	-0.604	0.55	0.025
Inspector 4	0.000	1.00	
housing free	-0.621	0.54	0.168
housing loose	-7.067	0.00	0.592
housing chain tie	-0.032	0.97	0.911
housing stanchion	0.000	1.00	
Month 1	0.678	1.97	0.290
Month 2	1.070	2.92	0.091
Month 3	0.541	1.72	0.421
Month 4	1.202	3.33	0.046
Month 5	0.536	1.71	0.379
Month 6	0.685	1.98	0.285
Month 7	0.894	2.45	0.142
Month 8	0.530	1.70	0.405
Month 9	0.452	1.57	0.449
Month 10	0.288	1.33	0.636
Month 11	-0.349	0.71	0.627
Month 12	0.000	1.00	
Year	-0.272	0.76	0.040

[a] Hosmer-Lemeshow goodness-of-fit statistic = 27.52 (p = 0.00)

REFERENCES

1. PLACE AR. Animal drug residues in milk: the problem and the response. J Dairy, Food and Envir Sanit 1990; 10(11): 662-664.

2. STENHOLM CW, WAGGONER DB. Moving beyond the rhetoric of food safety and meeting the challenge. J Am Vet Med Assoc 1992; 201: 234-239.

3. CROSS HR. New directions for food safety: A USDA perspective. J Am Vet Med Assoc 1992; 201: 240-241.

4. WEBER GM, WAGGONER DK, WAGGONER DB. Animal scientists and public communication: issues and methods. Prof Anim Sci 1992; 8:1-6.

5. POTTER ME. The changing face of foodborne disease. J Am Vet Med Assoc 1992; 201: 250-252.

6. WEAVER LD. Antibiotic residues in milk and meat: perceptions and realities. Vet Med 1992; 12:1222-1228.

7. BARR JC. A producer's perspective of food safety issues. J Am Vet Med Assoc 1992; 201: 242-244.

8. ESSLEMONT RJ. Computers in dairy farm management. Br Vet J 1988; 144: 351-362.

9. LAZARUS WF, SMITH TS. Adoption of computers and consultant services by New York dairy farmers. J Dairy Sci 1988; 71: 1667-1675.

10. GOODGER WJ, WEAVER L, REPP S, JAMESON C, EICKER S. The role of the veterinarian as production management advisor in the setup and use of computerized on-farm record systems - Part I. Compend Contin Educ Pract Vet 1989; 11: 233-238.

11. GOODGER WJ, WEAVER L, REPP S, JAMESON C, EICKER S. The role of the veterinarian as production management advisor in the setup and use of computerized on-farm record systems - Part II Compend Contin Educ Pract Vet 1989; 11: 349-353.

12. JALVINGH AW. The role of existing models in on farm decision support in dairy cattle and swine production. Livestock Produc Sci 1992; 31:351-365.

13. DOLUSCHITZ R. Expert systems for management in dairy operations. Comput Electron Agric 1990; 5 (1): 17-30.

14. DOMECQ JJ, NEBEL RL, MCGILLIARD ML, PASQUINO AT. Expert system for evaluation of reproductive performance and management. J Dairy Sci 1991; 74: 3446-3453.

15. JALVINGH AW, DIJKHUIZEN AA, VAN ARENDONK JAM. Dynamic probabilistic modelling of reproduction and replacement management in sow herds. General aspects and model description. Agr Systems 1992: 39:133-152.

16. BARTLETT PC, KANEENE JB, KIRK JH, WILKE MA, MARTENUIK JV. Development of a computerized dairy herd health data base for epidemiologic research. Prev Vet Med 1986; 4: 3-14.

17. DOHOO IR. Animal productivity and health information network. Can Vet J 1988; 29: 281-287.

18. KING LJ. Unique characteristics of the National Animal Disease Surveillance System. J Am Vet Med Assoc 1985; 186: 35-39.

19. RADOSTITS OM, BLOOD DC. Herd Health: A textbook of health and production management of agriculture animals. Philadelphia: WB Saunders, 1985.

20. BARTLETT PC, KIRK JH, MATHER EC, GIBSON C, KANEENE JB. FAHRMX: A computerized dairy herd health management network. Compend Contin Educ Pract Vet 1985; 7(2) S124-S133.

21. CROSSE S. Development and implementation of a computerized management information system (DAIRYMIS II) for Irish dairy farmers. Comput Electron Agric 1991; 6 (2): 157-173.

22. KELTON DF, MARTIN SW, HANSEN DS. Development and implementation of the Ontario Dairy Monitoring and Analysis Program. Proc Annu Conv Am Assoc Bovine Pract 1992; 1: 285-289.

23. DOHOO IR. Dairy APHIN - an information service for the dairy industry in Prince Edward Island, Canada. Prev Vet Med 1992; 12:259-268.

24. UNIVERSITY OF MINNESOTA. The DairyCHAMP Program User's Manual. 1st ed. University of Minnesota, 1989

25. ASHTON-TATE. Using dBase IV. Scotts Valley, CA: Ashton tate, 1988, 1992.

26. LOTUS DEVELOPMENT CORPORATION. 1-2-3 reference manual, release 2.01. Cambridge, Ma.: Lotus Development Corporation, 1987.

27. UDOMPRASERT P, WILLIAMSON NB. The DairyCHAMP program: A computerized recording system for dairy herds. Vet Rec 1990; 127: 256-262.

28. RICHARDSON HR. Standard Methods for the Examination of Dairy Products. 15th ed. Washington, D.C: American Public Health Association, 1985: 133-146.

29. IDETEK, INC. LacTek sulfamethazine milk screening kit. San Bruno. 1990

30. IDETEK, INC. LacTek beta-lactam milk screening kit. San Bruno. 1990.

31. STATISTIX Version 4. St. Paul MN: Analytical Software, 1985, 1992.

32. SCHUKKEN YH, SMIT JAH, GROMMERS FJ, VANDEGEER D, BRAND A. Effect of freezing on bacteriologic culturing of mastitis milk samples. J Dairy Sci 1989; 72: 1900-1906.

33. MCKINNON CH, ROWLANDS GJ, BRAMLEY AJ. The effect of udder preparation before milking and contamination from the milking plant on bacterial numbers in bulk milk of eight dairy herds. J Dairy Res 1990; 57: 307-318.

34. PANKEY JW. Premilking udder hygiene. Our industry today. J Dairy Sci 1989; 72: 1308.

35. THOMAS SB, DRUCE RG, KING KP. The microflora of poorly cleansed farm dairy equipment. J Appl Bacteriol 1966; 29: 409-422.

36. DIFCO LABORATORIES. Rapid detection of penicillin in milk. Detroit. 1980.

37. SENYK GF, DAVIDSON JH, BROWN JM, HALLSTEAD ER, SHERBON JW. Comparison of rapid tests used to detect antibiotic residue in milk. J Food Protec 1990; 53: 158-164.

38. BRIGHT SA. Tests for the detection of antimicrobial residues. Annu meet Natl Mastitis Counc 1991; 30:81-89.

39. CULLOR JS, CHEN J. Evaluating two new OTC milk screening ELISA's: Do they measure up? Vet Med 1991; 86(8): 845-850.

40. CULLOR JS. Tests for identifying antibiotic residue in milk: How well do they work? Vet Med 1992; 87(12): 1235-1241.

41. CULLOR JS, VANEENENNAAM A, DELLINGER J, PERANI L, SMITH W, JENSEN L. Antibiotic residue assays: Can they be used to test milk from individual cows? Vet Med 1992; 87(5):477-494.

42. RENEAU JK. Effective use of dairy herd improvement somatic cell counts in mastitis control. J Dairy Sci 1988; 69: 1708-1713.

43. SCHUKKEN YH, LESLIE KE, WEERSINK AJ, MARTIN SW. Ontario bulk milk somatic cell count reduction program. J Dairy Sci 1992; 75: 3352-3358.

44. SCHUKKEN YH, WEERSINK A, LESLIE KE, MARTIN SW. Dynamics and regulation of bulk milk somatic cell counts. Can J Vet Res 1993; 57: 131-135.

45. SAS User's Guide: Statistics, Version 6. Gary N.C.: SAS Inst., Inc., 1990.

46. GLANTZ SA, SLINKER BK. Primer of applied regression and analysis of variance. Toronto: McGraw-Hill, Inc, 1990.

47. KLEINBAUM DG, KUPPER LL, MULLER KE. Applied regression analysis and other multivariable methods. Boston: PWS Kent Publishing Company, 1987.

48. MCEWEN SA, BLACK WD, MEEK AH. Antibiotic residue prevention methods, farm management, and occurrence of antibiotic residue in milk. J Dairy Sci 1991; 74: 2128-2137.