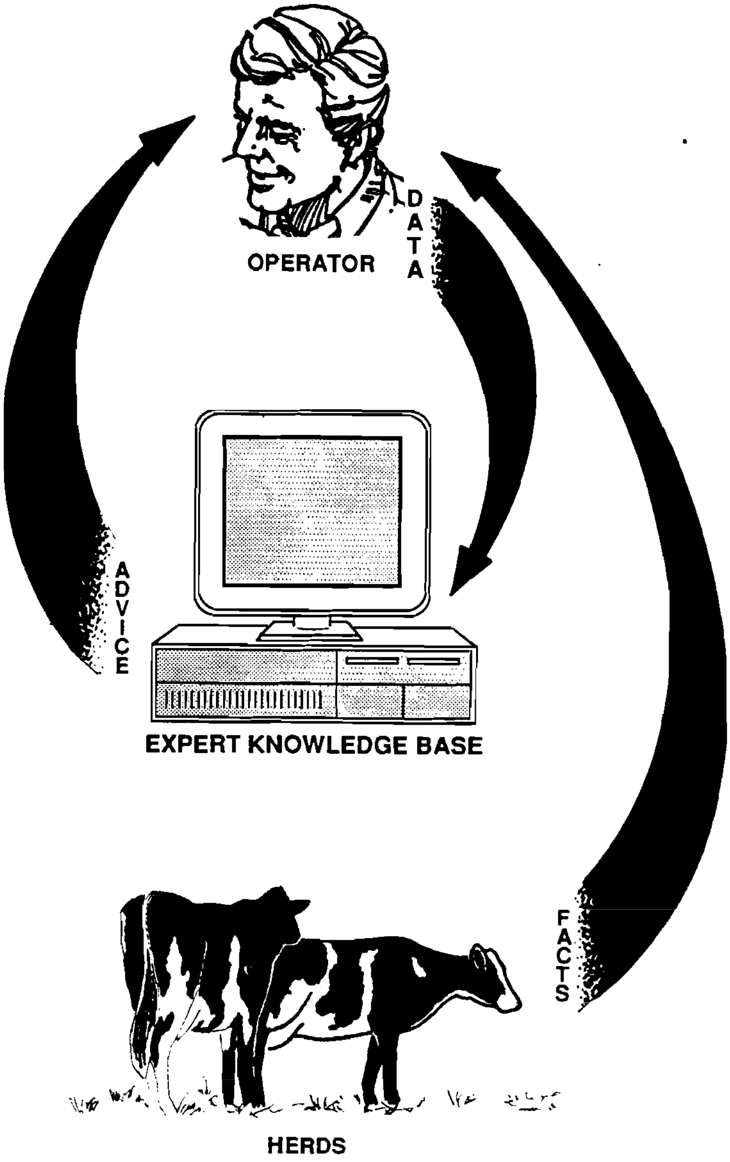
October 1991 A.E. Res. 91- 9

# DAIRYPERT™:

## AN EXPERT SYSTEMS APPROACH FOR IMPROVING DAIRY FARM MANAGEMENT PRACTICES AND ASSISTING TECHNOLOGY TRANSFER




Robert J. Kalter
Department of Agricultural Economics
Cornell University

and

Andrew L. Skidmore
Department of Animal Science
Cornell University

Department of Agricultural Economics
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York 14853

October 1991 A.E. Research 91-9

# DAIRYPERT™: AN EXPERT SYSTEMS APPROACH FOR IMPROVING DAIRY FARM MANAGEMENT PRACTICES AND ASSISTING TECHNOLOGY TRANSFER

Robert J. Kalter
Department of Agricultural Economics
Cornell University

and

Andrew L. Skidmore
Department of Animal Science
Cornell University

Knowledge Base Experts

Jack Albright (written documentation), Purdue University
James Ferguson, University of Pennsylvania
Leslie Ferreira, California Polytechnic State University
Wayne Knoblauch, Cornell University
Alex Kutches, O. H. Kruse Grain & Milling
William Merrill, Cornell University
Robert Milligan, Cornell University
Charles Sniffen, Michigan State University
Thomas Spike, Lilly Research Laboratories
Leon Weaver, University of California - Davis/Tulare
Participating Farm Test Sites

**ACKNOWLEDGEMENTS**

Research leading to the development of the DairyPert™ expert system and this publication was undertaken with the generous financial support of Elanco Animal Health, a Division of Eli Lilly and Company, and with additional support and funding from the Cornell College of Agriculture and Life Sciences.

**DISCLAIMER**

Results forthcoming from the expert system, DairyPert™, are based on data gathered by field personnel and the best judgments of experts in various disciplines as incorporated into the computer model. Cornell University and Elanco Animal Health in no way warrant the model's accuracy or utility in predicting the performance of, or diagnosing the management issues relating to, any individual business entity.

## ABSTRACT

This manuscript reports on the development an expert system (DairyPert™) for application to production dairy operations in the United States. The approach combines rule and model based components in a system that permits diagnostic evaluation of a dairy's current operations.

Neuron Data's NEXPERT shell is used for implementation. The shell is integrated with FoxPro database programs for data entry and delivery of system findings and results, and with an Excel spreadsheet containing the Cornell Net Carbohydrate and Protein nutrition model. Both IBM and Apple Macintosh personal computers are used as platforms for the effort.

The knowledge base is structured modularly to determine constraints to greater profitability and/or production in eight key management areas. The eight key areas are nutrition (including feed ration evaluations), physical facilities, herd health, reproduction, replacement, milking practices, herd management ability, and economic constraints (including risk factors). Heuristics or "rules of thumb" used by experts in these fields are used in conjunction with the nutrition model for diagnostic purposes.

For a number of the areas, input data, rules and system solution values are tracked separately for each of three facility types (freestall, corral or stanchion), for each physical enclosure or pen comprising the dairy operation, and for up to fourteen physiological animal classes within each enclosure. Thus, solution results are specified to a level of detail that permits the tendering of focused advice or management suggestions. Other key areas are concerned with problems of management and economics that relate to the overall herd situation.

During system operation, results are stored at the level of detail discussed above. However, recognizing that merely listing the findings could lead to information overkill, a second set of "rules" are used by the system to prioritize and tailor the advice provided. The principle objective is to match the type of advice given to the management ability and economic capacity of the farm operator, as well as to the expected economic payoff and payback period.

The resulting software package, using data for any dairy farm currently under an appropriate record keeping system, is capable of diagnosing dairy herd management problems and providing advice to the herd operator on how to correct such problems in a manner that will improve efficiency and production. The overall goal is to improve the short- and long-run management of and profitability from the dairy farm business and to prepare individual dairy operations for the adoption of new technology.

CONTENTS

TABLES

## ILLUSTRATIONS

## Section I

## INTRODUCTION

The long-term profitability and survival of a modern dairy farm is dependent on an understanding, by the farm operator, of the biological factors impacting milk production and knowledge of production economics and management. But the appropriate use of such knowledge and information is only a necessary and not a sufficient condition for economic success. That stems from the fact that economic results are constrained by numerous exogenous factors as well as by resource, financial, scale, and human capital constraints related to each individual farm. Over time, the ability to successfully adopt new technology and methods which will reduce production costs per unit of output is of equal importance. For it is only by the successful adoption of such practices that an industry is able to maintain or expand its market share against competing alternatives over the long-run; thereby providing the efficient individual farmer an opportunity to survive and prosper (Kalter and Milligan).

Management know-how and ability have traditionally been the limiting factors inhibiting improved production response from existing and newly adopted technology (Kalter). For over one hundred years, substantial public and private funds have been devoted to continuously maintaining and upgrading management skills through agricultural research and extension activities. In the future, these activities will become even more critical. The advent of personal computers, electronic communication, robotics and modern biotechnology are leading toward rapid advances in productivity by those capable of successfully adopting and utilizing their benefits (Bauman). Individual farm operators and the agricultural support system are being challenged as never before to make appropriate dairy and farm management decisions in light of these new technologies.

The interaction of key components in this framework makes the management task even more difficult. Failure to properly evaluate the biological and economic forces at work, and to react accordingly, may place large numbers of farm operators at a financial disadvantage and will almost certainly result in a less than optimal commercial introduction of new technology.

The complexity and synergism of decisions facing dairymen argues for the development of systematic methods that:

A. Provide assistance in improving management capabilities;

B. Permit simulation of possible management actions in order to forecast possible effects;

C. Allow for rapid response to management questions;

D. Account for the biological, economic, agronomic, engineering, and personnel aspects of the management problem; and

E. Consider the long-range strategic, as well as tactical, impacts of management decisions.[1]

As implied, expertise from a number of disciplines is required to adequately consider and evaluate the management options important to successful farm operation and technology adoption. Yet true expertise is often in short supply, available only at a high cost, and/or not present on a timely basis. Even when an expert in a discipline is available to assist in the diagnosis of problems, the evaluation of alternative solutions, training or general consultation with an individual farmer, it is rare that more than one disciplinary point of view would be accessible at a given time.

## AN EXPERT SYSTEMS APPROACH

Use of computer technology for integration and dissemination of the knowledge available from various disciplines may be one approach to the educational problems outlined above. Computer information or data banks are now commonplace throughout society and are increasingly valuable to commercial agriculture. But to assist in or provide expertise useful for making numerous short- and long-run management decisions requires advances in the use of computers that reach well beyond the now relatively simple agricultural data banks. One such approach is the implementation of computerized expert systems used in conjunction with data banks, and appropriate biological and economic models.

"Expert system" refers to a procedure, usually reduced to a computer program, that mimics the ability of experts in specific fields to make decisions given knowledge concerning the factual situation. Use of biological and economic models, developed on the basis of years of research, can supplement acquisition of that knowledge from standard methods of observation and data collection. Such systems, once designed and executed, can serve as highly useful decision aids for farmers, extension personnel, farm input suppliers and others making management changes or providing advice on the appropriate procedures to use for achieving increased efficiency and profitability.

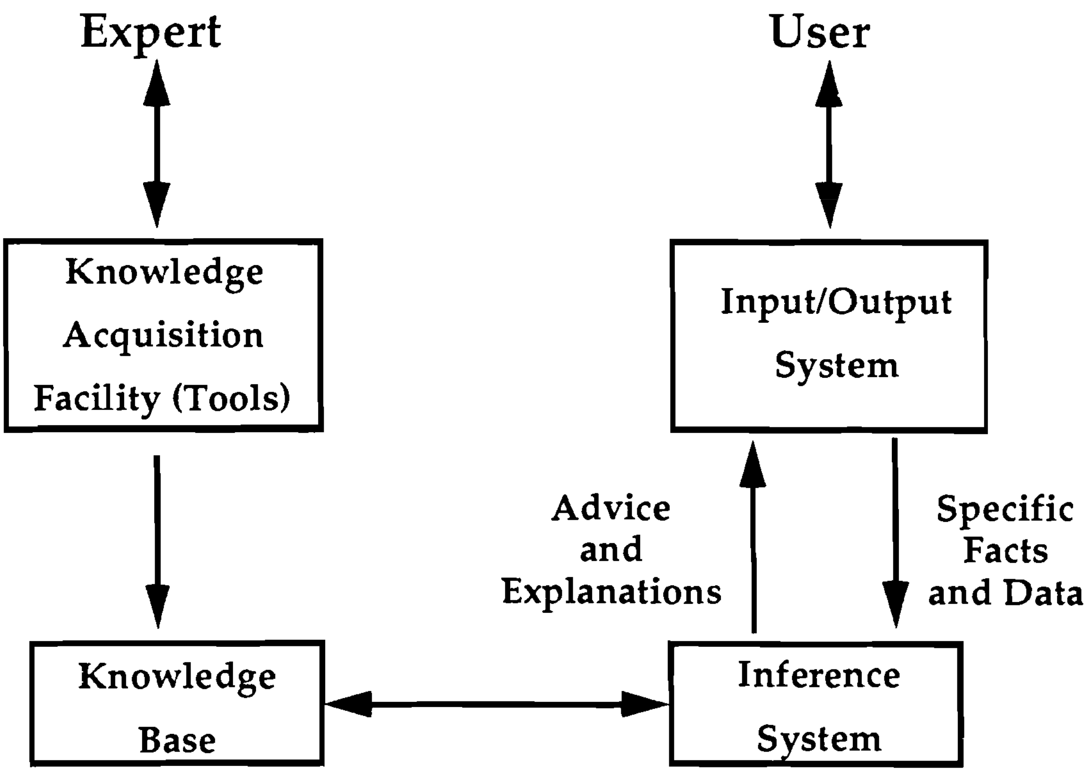
Expert systems adhere to no general standard but are usually developed and used following the components illustrated in Figure 1. First, one or more

---

[1]Strategic decisions relate to the overall, long-range business plan of an enterprise; while tactical decisions pertain to the hundreds of day-by-day choices necessary for execution of that plan.

human experts in a subject matter domain assist in developing a knowledge base that consists of both widely known facts and heuristic knowledge (rules-of-thumb, judgments, and experience-based guesses). Second, an inference engine or computer program (often called an expert system shell) is used in conjunction with the assembled knowledge base to form the key components of the expert system, itself. The inference engine contains the approach to problem solving implemented by the system. It is the manager of the system. That is, the shell handles all housekeeping chores like deciding which portions of the knowledge base to apply to a given problem, accessing the knowledge base, joining user supplied information with the expert opinion contained in the knowledge base to determine possible solutions to a problem, and performing follow-up actions based upon the findings relevant to the problem under investigation. Third, a natural language interface between the inference engine and the user is present to handle all input-output requirements, such as providing the shell appropriate facts and data about the specific problem under investigation and relaying results, explanations and advice to the user.

Figure 1.--Expert System Components



Expert systems are normally used in situations for which solutions based on mathematical computations are not the sole determining factor in problem resolution. Heuristic reasoning is necessary, often to supplement the results obtained from more traditional computer programs or analytical techniques. Optimization, in the mathematical sense, does not result. As such, applications can range from the large and complex to the focused and narrow.

Advantages: Conceptually, such systems have a number of advantages over the traditional approaches used for agricultural education and technology transfer. First, since these systems are usually computer based, they have the capacity to store and process the vast quantities of information and expert knowledge necessary for making management decisions. Because of this and the ability of the computer to be consistent through time, expert systems may be capable of equalling or surpassing the results achieved when using the services of a real live "expert."

Second, they eliminate the impossible task of having the few available "experts" in a given field consult with a geographically dispersed farm population. Rather, trained intermediaries can substitute for the expert with the assistance of the expert's knowledge as represented in the computer stored models and knowledge bases The time of the expert can then be devoted to expanding the field of knowledge, training the trainer, and consulting on unique problems that are not easily solved with the assistance of the computer based system.

Third, transfer of knowledge and advice can take place on a timely basis. Long lead times required to set-up appointments with experts are eliminated, the duplication of an expert system will increase the penetration of new knowledge throughout the target population as many trained individuals can provide assistance, and new research knowledge can be rapidly disseminated by relatively simple updates to the computerized knowledge bases and models.

Fourth, expertise from more than one discipline can be incorporated into the computer technique, so as to be simultaneously available to the farmer requiring assistance. Thus, a wider spectrum of considerations can be reviewed and potential conflicts between areas of concern can be identified and resolved early in the decision process.

Fifth, the nature and functionality of expert system environments are such that the end-user can have the ability to query the system. This ability allows the user to "ask why" the system is asking a particular question of the user and also allows the user to "ask how" the system has come to a particular conclusion or recommendation. Thus, expert systems developed for problem solving often contain the important side benefit of being useful for training and educating the end user by providing the ability to view the experts' reasoning process.

Finally, widespread use of computerized educational techniques, such as expert systems, can reduce the long-run costs of extending knowledge to an adult, working population. Fewer highly skilled teachers are required, teacher retraining costs can be reduced, and increased uniformity and accuracy in the information provided all contributed to this reduction in costs. Of equal importance, modifications in the knowledge base can be carried out rapidly and inexpensively because of the separation between the inference engine and the domain knowledge base.

Limitations: There are also limitations to the development and use of expert systems which must be recognized and dealt with. First, difficulty often arises in the acquisition of expert knowledge. "Experts" must cooperate with system developers and must be able to properly articulate their methods of reasoning about problems in a given subject domain. Second, the consideration of uncertainties, probabilities and/or ranges of results can be difficult to handle in the context of an expert system. Third, initial specification of a knowledge base structure and that of the supporting data bases can often be difficult, time consuming and permit the introduction of developer bias.

Despite these, and other, limitations, expert systems are gaining wide acceptance in business and government. Properly developed, the long-run benefits usually outweigh the costs.

## DAIRYPERT™: AN EXPERT SYSTEM FOR DAIRY MANAGEMENT

This manuscript reports on an effort to develop such an expert system (DairyPert™) for application to production dairy operations in the United States. The approach combined rule and model based components in a system that permits both diagnostic evaluation of a dairy's current operation and limited predictive analysis of changes, on a static basis, in management practices.[2] Heuristics or "rules of thumb" used by experts from a number of

---

[2] For an effort at building long-run predictive model to evaluate dairy herd management practices and technologies see Skidmore (1990).. The Skidmore model is a stochastic, dynamic simulation integrating nutrition, reproduction, production, growth, health and simple estimates of revenues and costs.. The model simultaneously simulates, using monte carlo techniques, discrete events such as disease, conception, heat detection and continuous processes such as growth and lactation. Nutrient requirements are derived from phenotypic lactation, growth, and pregnancy curves. Nutrient supply is derived from simulation of digestion and absorption of individual feed ingredients, and body tissue mobilization. Nutrients supplied are utilized in the following order of priorities: maintenance, pregnancy, growth, lactation, and body tissue repletion. Reproductive events are moderated by disease incidence, milk yield, energy balance, and management inputs. Milk yield is calculated from nutrient supply and adjusted for disease and reproductive events. Growth is determined by nutrient supply and is moderated by disease. Growth rate then determines time to puberty and size at first calving. Growth and body tissue

pertinent fields are combined with the "Cornell Net Carbohydrate and Protein" nutrition model (Fox et al., 1990). This model, based on dairy science research, predicts animal response to a prescribed ration using the latest in nutritional knowledge. Expert "rules of thumb" (or the knowledge base) are derived from a scientific understanding of the important biological and/or economic factors as discovered through research and honed by years of experience by an expert in a particular field.

The knowledge base is structured modularly to determine constraints to greater profitability and/or production in eight key management areas. While no system can be expected to handle all situations, this design allows for rapid inclusion of new data and information. The eight key areas are nutrition (including feed ration evaluations), physical facilities, herd health, reproduction, replacement, milking practices, herd management ability, and economic constraints (including risk factors).

Each of these key areas is, in turn, further subdivided into categories deemed important by the experts. For example, nutrition has a series of rules dealing with feed quality, feed quantity, minerals, dry cow rations, and milk cow rations. Feed quality is further subdivided into ration fiber, energy, degradable protein, soluble protein, fiber digestibility, starch digestibility, and trace minerals. Other key areas are structured in a similar fashion.

For a number of the key areas of inquiry, input data, rules and system solution values are tracked separately for each of three facility types (freestall, corral or stanchion), for each physical enclosure or pen comprising the dairy operation, and for up to fourteen physiological animal classes within each enclosure.[3] Thus, solution results are specified to a level of detail that permits the tendering of focused advice or management suggestions.

Other key areas are concerned with problems of management and economics that relate to the overall herd situation; not individual pens or physiological animal groups. Examples include general management ability, reproduction and replacement management and milking practices. However,

---

reserves are modelled independently. The incidence of fifteen metabolic, infectious, and other diseases that influence production are described by the model and stochastically modelled. The probability of occurrence is determined by incidence rate and risk factors such as production and other diseases. The result of disease is involuntary cull, production loss, or risk factor for another disease.

The model will simulate any period of time up to six years. Annual income from milk and cull animals is provided along with treatment and feed costs. Every animal in the herd is modelled individually from birth to death. The model lends itself to evaluate long-term benefits and risks of management practices and new technologies and can be used to define and customize optimum management strategies.

[3]These include nine milk cow groups (early, mid-, and late lactation first calf heifers, second calf heifers and third plus calf cows), a close-up and regular group of dry cows, a close-up group and regular group of bred heifers, and young stock over 400 pounds in weight.

the system does not encompass the entire farm management question; only concerns directly related to the dairy herd, itself, or to key factors pertinent to herd management. As a result, management constraints stemming from such areas as crop rotations, feed inventories, long-term capital investment and alternative animal enterprises are not considered.[4]

During system operation, results are stored at the level of detail discussed above. However, recognizing that merely listing the findings could lead to information overkill, a second set of "rules" are used by the system to prioritize and tailor the advice provided. This second rule set also depends on expert opinion and general information developed as part of the initial diagnostic process, but is applied outside the inference engine of the expert system through programming of the data based manager used for input/output control. Thus, factors like the level of milk production, an index of herd management ability, herd size, labor efficiency, profitability, risk factors and production cost information are used.

The principle objective is to match the type of advice given to the management ability and economic capacity of the farm operator, as well as to the expected economic payoff and payback period. By using available economic information in conjunction with known biological and physical constraints to higher profitability, advice that reduces the risk of exceeding the management and economic capacity (or tolerance) of the manager can be provided. This aspect of the system is intended to be modified with increased field experience and as experts in farm management review the results. Only with broad scale application of the system will enough feedback be obtained to enable the fine tuning of the approach to providing advice and guidance concerning a farm's dairy management problems. This will be an important follow-up research effort as the system is implemented.

---

[4]Micro economic constraints placed on a farm's strategic objective(s) impact the choice of tactical methods necessary to execute an appropriate farm plan. Clearly, however, modern dairy management must focus on the lactation and multi-lactation potential of a dairy herd. Macro economic and policy issues, whole farm profitability, and other resource constraints are incorporated only by assumption and sensitivity analysis rather than through optimization or modeling techniques.

On the other hand, biological response depends on genetics, management, feed rations, and herd health among others. Subsumed under these factors are numerous questions that must be dealt with to achieve optimal economic performance. Included are issues related to feed rations, lactation length, reproductive management, milking frequency, herd health, interactions between technological advances, and economic, as opposed to biological, responses. Consequently, a tool designed to improve management practices will need to account for these factors and their interactions.

OUTLINE OF REMAINING SECTIONS

The remainder of this report is divided into three sections and three appendices; each providing detailed background on aspects of the development, implementation and use of DairyPert™.

Section II discusses expert system concepts, including the structure of a knowledge base, reasoning techniques, and methods for factual representation. This background is then used in Section III to discuss the specific DairyPert™ implementation (including the various components and their links), the logic and structure of the rules used, the approach used for data acquisition, and the method developed for displaying results and suggestions. The basic nutrition evaluation model used in conjunction with the knowledge base is also described along with modifications made to the original model for purposes of the DairyPert™ system. Finally, the problems of model validation and results of the validation process used to date are discussed. Section IV offers a brief conclusion to the research aspect of the project and a short discussion of possible future model enhancements.

Appendix A outlines the hardware and software requirements necessary to utilize the system in the field, and provides a guide to the actual use of the system. **The software is available to individuals in the public sector (Universities, Government, Federal/State Extension Service Offices and the Diary Herd Improvement Association [DHIA] Offices) from the authors for a small fee. Others should contact Elanco Animal Health, a Division of Eli Lilly and Company, in Indianapolis, Indiana to obtain copies of the software.** For those who want to get started, Appendix A should be read next. References or sources for the various categories of rules developed are contained in Appendix B. Finally Appendix C provides a set of data acquisition forms (barn sheets) that can be reproduced and are to be used during the data gathering phase of system operation. **Separate packets of the barn sheets are available from the authors for the cost of reproduction and mailing.** Appendix C also explains the use of these forms and attempts to answer often asked questions about the "farm visit." A complete description of the Cornell nutrition model that was used as basis for the model incorporated into the expert system is available from the publication Fox et. al.

Section II

# EXPERT SYSTEM CONCEPTS

"The purpose of an AI knowledge-based system is to transform the line of thought of a human expert into a set of formalized symbolic operations so as to reproduce his or her expertise" (Neuron Data, 1988). Thus, problem definition, description and solution by an expert system depend upon the ability of the associated computer model to contain and process both knowledge (reasoning) and data dimensions. Expert knowledge is represented by *rules. Data,* or exogenously supplied information of a factual nature, is usually represented by structures that have a hierarchical nature and that are related to the problem area being investigated.

Data representation is independent of knowledge representation but the two are mutually supporting in the solution process. That is, knowledge utilization cannot proceed without specific information about the factual circumstances of the problem being investigated. Likewise, the representation of factual information must be structured, gathered and stored in a manner that relates to the reasoning process of the expert.

This section will describe these two aspects of an expert system in more detail and will outline the various concepts, components and linkages used for the research effort reported here. Although all expert systems "shells" use similar logic, some are more sophisticated than others or handle key concepts in different ways. In the discussion that follows, the structure used by Neuron Data (1988) in developing their NEXPERT shell provides the basis for outlining the concepts involved. NEXPERT was the shell selected for implementing DairyPert™ because of it's completeness, flexibility and ability to handle large numbers of rules and data sources.

## EXPERT SYSTEM RULES

A single rule in an expert system contains a portion of the knowledge and/or intuitions used by an expert in analyzing a particular situation and its immediate result. Its symbolic structure takes the form:

if ... then... and do ...

when *if* refers to a group of conditions, *then* refers to a hypothesis or goal that is true if <u>all</u> the conditions are also true, and *do* refers to a set of actions undertaken if the hypothesis is declared true. Rules are usually specified based upon the knowledge of one or more "experts" in the subject matter area, although specific conditions within the *if* portion of the rule may be detailed by reference to relevant scientific literature or other sources.

The expert system knowledge base is composed of many such rules covering the subject matter domain under investigation. Investigation of individual rules in the knowledge base can cause other rules to be evaluated or can verify conditions in other rules. Thus, a chain or path of "reasoning" can develop leading to problem solutions.

However, a rule can only be evaluated if the datum involved in the various conditions making-up the "if" clause are known. When this occurs, the rule becomes "relevant" and can be used to make inferences. Only if all the conditions making up the "if" portion of the rule are known *and* true can the associated hypothesis be declared true. Thus, when a rule is evaluated, the hypothesis takes on a boolean value (true/false). If the value is "true," this is known as a rule being "fired."

If a rule's conditions require knowledge of the boolean state of another rule, the system will try to evaluate the other rule as a part of the evaluation process. This is known as backward chaining or deductive reasoning. It is equivalent to having the inference engine use a goal-driven strategy. Backward chaining can proceed to many levels of depth and involve numerous rules if the structure of the "expert's" reasoning process demands.

When certain actions are taken as a result of a rule being "fired," such as changing or introducing the value of data, rules for which data were not previously available to test conditions may be evoked. This is known as forward chaining or reasoning. It is equivalent to having the inference engine use a data-driven strategy. Also, rules previously evaluated may be placed back on the agenda for reevaluation due to an action which modifies the state of a condition.

Backward and forward chaining are completely interdependent. Although some inference engines operate using only one strategy, sophisticated algorithms, such as NEXPERT, use a combination of the two and optimize solutions by convergence. Any given hypothesis can be placed on the agenda in response to internal or external factors that make it relevant to the problem. Moreover, any given action can be constrained from affecting the system's agenda or focus by mechanisms (called *Strategies*) defined by the expert.

Once a rule has been fired, certain defined actions may be called for by the rule's structure (although actions are not required to have a complete rule). For example, the following are all possible actions after a rule firing:

- Change the value of one or more data;

- Read/Write in databases;
- Display graphics and/or text;
- Reset one or more system values;
- Execute external programs;
- Bring new sets of rules into play; and
- Bring new sets of data into play.

Finally, sets of rules (two or more) that are directly tied to each other by condition, hypotheses or action requirements are called "knowledge islands." In other words, rules in a knowledge island are linked to each other by two or more rules sharing common hypotheses, conditions or action requirements. All rules in an island need not share a common link; rather links can develop in a cascading manner. Such rules are known as having strong links; that is, exploration of one will trigger the attempted evaluation of all the rules in a set or knowledge island.

A given expert system, however, may contain numerous knowledge islands. These islands can be linked by what are known as "weak linkages." Under these conditions, links are prespecified between different knowledge islands. When that occurs, evaluation of a hypothesis contained in one island (the source) automatically causes the second island (the target) to be placed on the system agenda for review. Thus, an expert's intuition about connecting factors can be investigated even though no direct relationship exists between data elements, hypotheses or actions.

## EXPERT SYSTEM DATA REPRESENTATION

Rules contained in a system's knowledge base can access factual information as one means of verifying the true or false status of conditions. This factual information, relevant to a problem, is normally organized in a hierarchical structure that facilitates data collection, the evaluation by system rules, and the focusing of actions on relevant portions of a problem. The structure, itself, is usually dictated by the nature of the subject matter area and the reasoning process of the expert(s) used.

In NEXPERT, this structure takes the form of "objects, properties, and classes." The basic unit of information description is the object. Properties are characteristics of objects. For example, an object may be a pen of dairy animals which can have the properties of physical size, access to water, shade, etc. A class is a collection of objects that share properties. All the animal pens on a particular farm may form a class; with each object being a specific physical enclosure. Thus, data or information can be stored by classes, objects, and properties. Information relevant to each object in a class can be stored at the class level and "inherited" by the objects when necessary. As a result, a class can be rapidly culled of all the objects that meet a certain condition (property). This is known as pattern-matching and is used extensively in DairyPert™ to, for example, isolate problems to specific pens of animals.

An object can belong to more than one class and also can be components of other objects if called for by the structure of the problem being investigated. This permits complex inheritance schemes for the values of properties to be established. Property values can also be derived from external sources and are completely controlled by defining an "order of sources" within the system. Thus, a given data element might first be sought by investigating whether it is known for the class and whether the class value applies to the specific object in question. Failing that, the system can switch to a different source; say an external routine to calculate the necessary item or to an existing data bank.

## CONCLUSION

The concepts upon which expert systems are based provide an extremely powerful, yet flexible, set of tools for evaluating problems that lend themselves to qualitative reasoning, association building and serendipitous thought processes. Intelligent use of such tools can lead to the development of techniques that aid the spread of knowledge and assist non-experts in improving productivity and business profitability. The next Section will detail one attempt at such a mechanism in the subject domain of dairy herd management.

Section III

# DAIRYPERT™ IMPLEMENTATION

Implementation of the expert system architecture outlined in the previous section for purposes of diagnosing dairy management practices required development of the knowledge base from expert opinion and the scientific literature, specification of the natural language interfaces for information input and output, and modification of an existing model used for feed ration evaluations. This section will detail the procedures used in each of these areas. First, however, the general concepts used to formulate the DairyPert™ system will be reviewed. At the end of the section, the issues of model validation and implementation requirements will be addressed.

## DAIRYPERT™ ARCHITECTURE

DairyPert™ utilizes rules developed on the basis of expert opinion and scientific information to diagnose potential problems of dairy productivity and profitability. Factual information and data from observation of an individual dairy, developed using a structured questionnaire administered to the farm manager and from the results of analyses of animal feed rations, are used in conjunction with these rules. The focus is on dairy herd management and economics and not on the management of an entire farm operation. Thus, some aspects of the business enterprise are not covered by the resulting analysis. Problem solutions and the suggestions forthcoming must, therefore, be considered accordingly.

Figure 2 details the architecture of the DairyPert™ program. As discussed above, it consists of an information acquisition and data entry component, a nutrition model that evaluates feed rations entered as part of the data entry routine, a knowledge base consisting of expert derived rules, the expert system inference engine or solution algorithm (also known as the "shell"), and a module that handles the display and printing of solution results and appropriate advice. In addition, elements of the system are linked to each other using DDE (Dynamic Data Exchange) methods available under Windows 3.0 for IBM compatible personal computers and under System 7.0 of the Apple Macintosh operating system. To the extent permitted by the various application programs used, this provides a common user interface for the entire system and makes the various components transparent to the final user.

Figure 2.–DairyPert Flow Chart

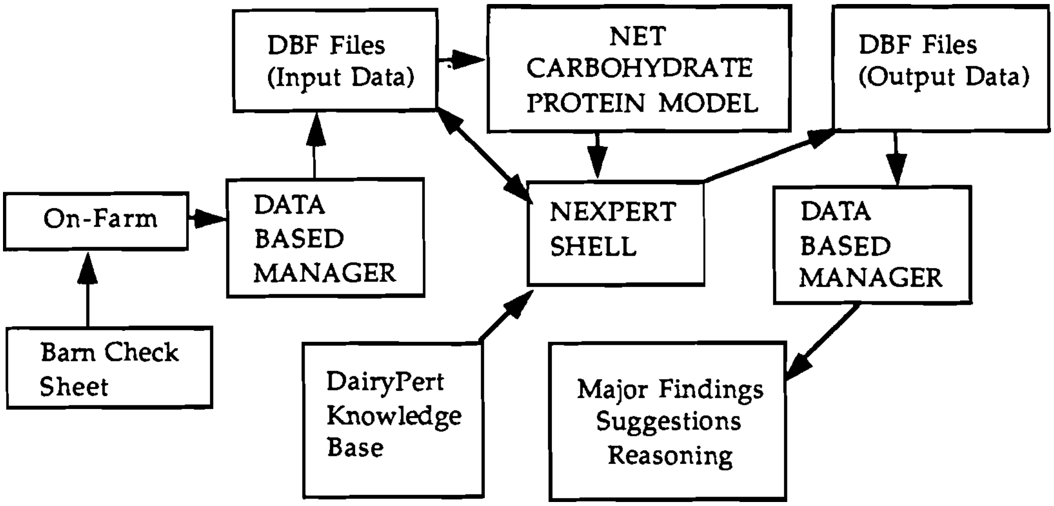



Table 1 outlines the eight key management areas encompassed by the DairyPert™ rules, and their subdivisions. The various rule categories result from the approach to farm evaluation taken by the experts involved in specifying the rules and their linkages. As indicated, some rules apply to individual animal pens and physiological animal classes within pens, while others are related more generally to herd or general management issues relevant to the overall dairy operation.

The input and output interfaces for the expert system were designed and programmed using a database management software package (FoxPro for IBM compatible computers and FoxBase for Macintosh systems). Data acquisition supports the knowledge base specified. Information is collected, using a structured questionnaire, via an on-farm visit from a trained observer. Completion of the questionnaire requires an in-depth interview with the farm operator or manager and a comprehensive walk through all the facilities (animal pens, milking areas, feed storage locations, etc.). Information observed on this walk through is a vital portion of the questionnaire and must include body condition scoring of animals in individual pens and physiological groups. The results of this interview and observation process are then entered into a computer data base by a series of entry screens that correspond to the written questionnaire.

As part of the data acquisition and entry routine, the content and chemical evaluation of all feed rations used on the farm are entered into the computer. This information is used by the Cornell Net Carbohydrate and Protein System to evaluate the adequacy of the cattle diets given the rate of production and/or expected growth. The feed evaluation model is used to independently evaluate the adequacy of feed intake for each physiological

Table 1

KEY AREAS OF MANAGEMENT FOCUS AND THEIR SUBDIVISIONS

| KEY AREAS | SUB-AREAS | DIVISIONS | APPLICATION |
|---|---|---|---|
| **Nutrition** | | | |
| | General | | Pens/Animal Cl. |
| | Feed Quality | | |
| | | General | Pens/Animal Cl. |
| | | Ration Fiber | Pens/Animal Cl. |
| | | Ration Energy | Pens/Animal Cl. |
| | | Ration Degradable Protein | Pens/Animal Cl. |
| | | Ration Soluble Protein | Pens/Animal Cl. |
| | | Fiber Digestibility | Pens/Animal Cl. |
| | | Starch Digestibility | Pens/Animal Cl. |
| | | Trace Minerals | Pens/Animal Cl. |
| | Feed Quantity | | Pens/Animal Cl. |
| | Dry Cow Ration | | Pens/Animal Cl. |
| | Milk Cow Ration | | |
| | | Dry Matter Intake | Pens/Animal Cl. |
| | | Sequence of Feeding | Pens/Animal Cl. |
| | Minerals | | Pens/Animal Cl. |
| **Physical Facilities** | | | |
| | General | | Pens/Animal Cl. |
| | Bunk Space | | Pens/Animal Cl. |
| | Cow Comfort | | Pens/Animal Cl. |
| | Facilities Management | | |
| | | Stall Maintenance | Pens/Animal Cl. |
| | | Walking Ease | Pens/Animal Cl. |
| | | Bedding | Pens/Animal Cl. |
| | | Manger | Pens/Animal Cl. |
| | Manger Access | | Pens/Animal Cl. |
| | Ventilation | | Pens/Animal Cl. |
| | Water Quality | | Pens/Animal Cl. |
| | Water Quantity | | Pens/Animal Cl. |

Table 1 Continued

| | | | |
|---|---|---|---|
| **Herd Health** | | | |
| | Feed Practice | | Pens/Animal Cl. |
| | Sanitary Practice | | Pens/Animal Cl. |
| **Reproduction** | | | |
| | Cull Rate | | Herd |
| | Retained Placenta | | Herd |
| | Maternity Pen Management | | Herd |
| | Pregnancy rate | | Herd |
| | Heat Detection | | Herd |
| | Early Breeding | | Herd |
| | Dry Period | | Herd |
| **Replacement** | | | |
| | General | | Herd |
| | Young Stock Management | | Herd |
| **Milking Practices** | | | Herd |
| **Herd Management Ability** | | | Herd |
| **Economics** | | | |
| | Cash Flow | | Herd |
| | Cost Control | | Herd |
| | Debt | | Herd |
| | Profitability | | Herd |
| | Milk Production Rate | | Herd |
| | Herd Size | | Herd |
| | Labor Efficiency | | Herd |
| | Risk | | Herd |

group in each pen. However, the capability of that system was substantially modified for use in conjunction with the expert system. Those modifications are outlined in more detail below.

The output routine is of most interest to the final user since it is the vehicle for displaying the conclusions reached by the expert system and for providing suggestions based upon those conclusions. The routine contains an independent set of rules (separate from those used to diagnose potential management problems) for making decisions on how conclusions and suggestions will be displayed. This routine attempts to evaluate end-users needs and capabilities prior to displaying suggestions, and tailors that display to those needs and capabilities. Both the input and output routines will be discussed in more detail below.

## RULE FORMULATION

Rule formulation is a complex, interactive and often serendipitous process. The authors, acting as knowledge engineers, assembled information for rule specification in several ways. Of prime importance, experts in the key areas covered by the expert system were asked to detail how they analyze dairy operations for constraints on production and long-run profitability. Unstructured and semi-structured taped interviews were used to initiate this process. Tape transcriptions were made and given to the "experts" for review, correction and relevant additions. Follow-up interviews were conducted in several cases to obtain additional clarification and information. Conflicting views of overlapping experts were identified and clarified with the individuals concerned. This often resulted in further partitioning of an interest area.

Once final transcripts had been obtained, the authors "mined" the information for potential rules and began to specify those rules using the expert system shell's rule editing functions. As part of this process, rules were assigned to one or more modules denoting key interest areas and appropriate links between and within areas of knowledge were developed.

Figure 3 displays an example of such a rule. The rule displayed resides in the knowledge island dealing with physical facilities and, specifically, examines one aspect of bunk space adequacy. The name of the rule (Bunk_Space_Ground) is displayed at the top left portion of Figure 3. Along the left side of Figure 3 are listed the various "If" statements that must all be declared true if the hypothesis (namely, that there is a possible constraint on bunk space per cow) is to be fired or declared true. The hypothesis, itself, is displayed at the top right side of Figure 3. Under the hypothesis, is an action statement that will be carried out only if the hypothesis is fired.

The statements making-up the "If" or left side of Figure 3 all contain two or three components; depending upon the exact type of condition being invoked. Each statement has a test operator, a first argument field (holding data or an expression the test operator acts on), and a second argument field (holding a constant that the first argument can be measured against). Thus, in the example, statements are tested to determine if any of the physical enclosures present on the farm (<|Pens|>) contain milk cows, are freestall or corral facilities, do not have headlocks, have an elevated bunk, fail to separate mature cows from first calf heifers, and have less than 1.5 feet of bunk space per cow and feed less than twice a day. If all of these statements are true for

Figure 3.--Expert System Rule Example

| **Rule Name:** Bunk_Space_Ground | | | | |
|---|---|---|---|---|
| **IF:** Is | <\|Pens\|>.Animal_maturity | "Milk Cows" | ➡ **Bunk_Space_Const.** | |
| Is | <\|Pens\|>.Type | "Freestall", "Corral" | Let <\|Pens\|>.XB4 | True |
| No | <\|Pens\|>.Headlocks | | | |
| No | <\|Pens\|>.Elevated Bunk | | | |
| < | <\|Pens\|>.Bunk_space/cow | 1.5 | | |
| < | <\|Pens\|>.Freq._of_feeding | 2 | | |
| No | <\|Pens\|>.Sep_1st_calf_heifers | 2 | | |

any physiological group of animals in any given physical enclosure being evaluated, the hypothesis is fired with respect to that group. The shell automatically keeps track of which groups and pens are impacted by the rule firing and stores that result as a boolean value (True) in a separate class of objects (XB4) through the action statement on the right side.

As indicated above, rules were developed in a manner that permitted evaluations of individual animal enclosures and for up to fourteen physiological animal groupings within each enclosure. The system allows for all types of enclosures (freestall, corral, or stanchion) to be present on a given dairy operation. Areas of inquiry often required that separate rules be developed for the various types of enclosures being considered. For example, adequacy of bunk space requires a set of rules that are applicable to corral and freestall operations but are meaningless in a pure stanchion situation. Alternatively, a stanchion operation should be concerned with animal grouping and/or the use of manger partitions.

In addition to using expert knowledge as a basis for rule formulation, relevant articles from the scientific literature were used to develop rules in areas not covered by our cooperating experts or for which supplemental information was required. Rule formulations developed in this manner were verified with one or more of our experts in closely related areas of interest.

Once initial rule formulation had been completed in a key interest area, the results were shared with the expert for further clarification and possible modification. After this process was completed, a series of tests were completed on farms throughout the major dairy regions of the country. Tests results were compared with those obtained by an "expert" evaluating the same dairy operation. The results of these tests and comparisons were then used to further clarify, modify and augment the knowledge base. New linkages between rules and between various knowledge islands were also developed as a result of this process.

The final knowledge base consists of over 314 rules not including the techniques used for entering data or retrieving solution results. Table 2 lists the number of rules developed for each key interest area and subarea. Appendix B indicates references for the various expert rule categories contained in the completed system.

## CORNELL NET CARBOHYDRATE AND PROTEIN SYSTEM

The research monograph describing the stand-alone Cornell Net Carbohydrate and Protein ration evaluation model is available in the separate publication by Fox et. al. This model was modified for use as a component of the expert system. This section will detail those modifications.

First, the original Cornell ration model was developed using Lotus 123. For use here, the authors reprogrammed the model using Excel. Doing so made it possible to transport the model formulation between IBM compatible and Apple Macintosh computer platforms without modification. This allowed for a simplified development and modification process.

Second, the original Cornell model was able to evaluate only one ration at a time. This was unacceptable for purposes of analyzing the adequacy of feed rations fed to animals in numerous physical pens and/or to the various possible physiological animal groupings in each pen. The entire process needed to be automated. Thus, the model was modified to sequentially evaluate all the rations being fed and to store the results for further processing by the expert system shell.

Third, a component was added to the model that tested for the availability of eight minerals (8) in each ration tested. Required mineral amounts are calculated based upon the physiological animal group being evaluated and their needs for milk production and/or growth. Required amounts of the eight minerals are then compared to that supplied by the various components of the ration to determine if deficiencies exist or, in some cases, if excessive amounts are being fed. The mineral composition of the feed ingredients is based on either default values from the National Research Council (NRC) feed library or from chemical analyses of the actual feed supplied by the farm operator. These results, like others forthcoming

Table 2

RULE NUMBERS PER MANAGEMENT FOCUS AREA

| AREA | SUB-AREAS | DIVISIONS | RULE NUMBERS |
|---|---|---|---|
| **Nutrition** | | | **77** |
| | General | | 4 |
| | Feed Quality | | |
| | | General | 8 |
| | | Ration Fiber | 2 |
| | | Ration Energy | 5 |
| | | Ration Degradable Protein | 3 |
| | | Ration Soluble Protein | 5 |
| | | Fiber Digestibility | 2 |
| | | Starch Digestibility | 3 |
| | | Trace Minerals | 2 |
| | Feed Quantity | | 11 |
| | Dry Cow Ration | | 5 |
| | Milk Cow Ration | | |
| | | General | 14 |
| | | Dry Matter Intake | 2 |
| | | Sequence of Feeding | 3 |
| | Minerals | | 8 |
| **Physical Facilities** | | | **63** |
| | General | | 8 |
| | Bunk Space | | 6 |
| | Cow Comfort | | 16 |
| | Facilities Management | | |
| | | Stall Maintenance | 2 |
| | | Walking Ease | 4 |
| | | Bedding | 2 |
| | | Manger | 3 |
| | Manger Access | | 3 |
| | Ventilation | | 4 |
| | Water Quality | | 7 |
| | Water Quantity | | 8 |

Table 2 Continued

| | | | |
|---|---|---|---|
| **Herd Health** | | | **4** |
| | Feed Practice | | 1 |
| | Sanitary Practice | | 3 |
| **Reproduction** | | | **27** |
| | Cull Rate | | 5 |
| | Retained Placenta | | 2 |
| | Maternity Pen Management | | 9 |
| | Pregnancy rate | | 3 |
| | Heat Detection | | 2 |
| | Early Breeding | | 4 |
| | Dry Period | | 2 |
| **Replacement** | | | **9** |
| | General | | 4 |
| | Young Stock Management | | 5 |
| **Milking Practices** | | | **7** |
| **Herd Management Ability** | | | **81** |
| **Economics** | | | **46** |
| | Cash Flow | | 4 |
| | Cost Control | | 4 |
| | Debt | | 4 |
| | Profitability | | 2 |
| | Milk Production Rate | | 12 |
| | Herd Size | | 4 |
| | Labor Efficiency | | 15 |
| | Risk | | 1 |

from the ration evaluation, are then used by the knowledge base to further pinpoint potential or actual problems.

Fourth, the original model did not allow for easy entry of feed ingredient chemical analyses. Modifications in the default feed library values need to be made when such analyses are available. Since actual chemical analyses often differ substantially from the NRC supplied default values and since the availability of such analyses is becoming commonplace, an easier approach seemed appropriate. Thus, the model was modified to permit direct entry of changes in the chemical values of any feed ingredient for any ration via the natural language input interface. These values do not destroy or write over the NRC defaults present in the feed library but can be stored for a given farm and can, thus, be used without reentry in conjunction with other feed rations using the same ingredient(s).

Fifth, the addition of a "new feed" module allows the user to input feeds that are not contained in the existing Feed Library. The existing library is made-up of feed ingredients whose chemical aspects have been characterized by the NRC. The "new feed" module allows entry of a feed which may not be present in the NRC listing, using a specific identification number, and all of its chemical composition values. There is also an option for saving these feeds to the Feed Library for continuing use on other dairies. Otherwise, none of the new feeds entered will be saved when a given evaluation is completed. Information on new feeds is obtained during the farm inspection. Both the new feed identification numbers and their associated chemical analyses are entered into the system through a component of the nutrition model and not through the data input module.

Sixth, the original nutrition model did not allow for more than nine (9) forages and concentrates to be present in a ration at one time. The ration evaluation model only handled nine feeds because of the formula size limitation for spreadsheet cells. This, however, may be inadequate in some situations. The new "combine feeds" option permits this constraint to be relaxed. If more than nine feeds are present in a ration, some can be combined and a weighted average of their chemical compositions and other values calculated as a means of meeting the restriction. Up to three (3) feed ingredients can be combined at one time. However, up to fifteen (15) "combined feeds" can be present in a given ration; allowing for up to forty-five (45) ingredients to be present in a given ration. Like the "new feeds" option, any chemical analysis for ingredients in a combined feed is entered through the combined feed entry process on the Excel spreadsheet and not through the data input module.

## NATURAL LANGUAGE INTERFACE - INPUT

The DairyPert™ entry program consists of a number of "smart" entry screens that follow the format of the questionnaire used for the initial interviews with the farm operator. Appendix C contains the questionnaire and instructions for its use.

First, the program clears a number of database files (from previous sessions) in order to reload these files with the data for the farm under consideration. Several screens of general information about herd production, number of physical pens or enclosures, number of animals per enclosure and type of enclosure are then requested. Next, a set of screens requests physical facility information pertinent to each pen or enclosure. These screens repeat (with some variation for each type of pen - corral, freestall, stanchion) for each enclosure present on the farm. Next, information pertinent to evaluating rations and feeding characteristics is requested. These screens repeat for each physiological group in each enclosure and, in turn, for each enclosure. Finally, sets of screens dealing with reproduction, replacement, economic issues, and general dairy management questions are displayed. These latter screens do not repeat since they request general information applicable to the entire herd and not data pertinent to a specific physical enclosure or physiological group of animals.

The entry screens are "smart" in several ways. The entry routine understands:

A. The type of facility being considered at each point in the entry process and displays only questions pertinent to it (corral, freestall or stanchion);

B. The answers to questions which will elicit related questions or eliminate follow-up responses;

C. The rations used for various animal groups and the feed ingredient composition of those rations.

The latter eliminates the necessity of entering similar ration ingredients for each enclosure or physiological group of animals being evaluated.

The results of the computerized questionnaire are stored as DBF3 format files for further processing by the expert system shell and as CSV format files for processing by the Excel resident nutrition model.

## NATURAL LANGUAGE INTERFACE - OUTPUT

The results of the nutrition model solution and data on other aspects of the dairy operation are utilized by the knowledge base and expert system module to reach numerous conclusions about performance and management of the farm being evaluated. These conclusions are also stored in DBF3 format for retrieval by a natural language output module. That module displays the conclusions reached and provides follow-up suggestions. Results are provided for both overall dairy operations and with respect to individual animal enclosures and animal groups within those enclosures when appropriate.

However, the output routine is programmed with a number of rules that govern the manner and form by which results are displayed. Suggestions are classified by the degree of management difficulty involved in their implementation, by their impact on capital and operating budgets, and by their relationship to other problem areas determined by the solution.

This classification is used in conjunction with an evaluation of the dairy operator's management ability, financial condition and scope of management problems to develop priorities for the suggestions provided and for determining how a specific piece of advice should be tailored for the operator. For example, lack of high level management expertise on the part of an operator could result in the withholding of suggestions dealing with the balancing of protein fractions within a feed ration. The operator simply may not have the knowledge, at that point in time, to understand or implement the suggestions.

Priority is given to suggestions which impact or apply to all the physical enclosures and animal groups in the dairy operation (as opposed to those relevant only to a given pen or group). The former has been deemed by most of our experts as signifying a generic problem that should take first priority.

Finally, since little is known, at the micro level, of the impact that a given suggestion can have on the bottom line of an annual profit-and-loss statement, the order of suggestions by key management area is developed arbitrarily; with nutrition and physical facilities considered first for any given pen or animal group. As more experience is gained with use of the system and the management actions that it's use may engender, this order of results can be modified to reflect common management objectives.

## VALIDATION

Scientific validation is difficult for any effort of this sort (Masuch, p. 5, Vasarhelyi, pp. 14-16). "Before/after" analysis is not valid given the number of factors, both endogenous and exogenous, that can change with time. The heterogeneity of the dairy farm population makes any "with/without" evaluation nearly impossible to perform. Vasarhelyi (pp. 14-16) suggests that:

> Validation ... entails comparing outcome measures between the model and the experts that were used during the knowledge acquisition and knowledge representation stages. If significant differences are found, the developer must tune the model. Tuning is a process that involves reverting to the knowledge acquisition or knowledge representation stages to extract and represent additional facts or heuristics that will enable the computational model to pass this stage of the validation process.

Masuch (p. 5) suggests an alternative approach to the validation issue.

> There are six important criteria for validation: (1) the *accuracy* of the *knowledge base*; (2) the *completeness* of the *knowledge base*; (3) the *adequacy* of *knowledge-base weights*; (4) the *adequacy* of the *inference mechanism*; (5) the *adequacy* of *condition-decision matches*; and (6) the *soundness* of the *inference engine* (finding the right answer for the right reasons).

During the development process for DairyPert™, great care was taken to correspond with these criteria. Knowledge base accuracy was ascertained by carefully selecting relevant knowledge sources and verifying rules against the scientific literature. Completeness was ensured by using systematic procedures for examining knowledge sources and by cross-checking knowledge islands against each other.

Knowledge-base weights are not a substantial problem with a diagnostic system like DairyPert™ since rules are generally not weighted in the discovery process. However, as discussed above, a weighting scheme is utilized in providing the results of system solutions to the potential user. This aspect of the effort clearly needs to be reviewed as additional experience is gained with the use of the system.

The adequacy of the inference mechanism was a major factor in the choice of the expert system shell used to implement DairyPert™. Nexpert was chosen precisely because of it's robust nature, approach to the reasoning process and wide-spread use among business and scientific professionals. The condition-decision match criteria is similar to the validation approach suggested by Vasarhelyi and discussed above. Finally, the soundness of the inference engine relates to whether the "shell" provides the "right answer for the right reason." Again this issue was evaluated using the methods suggested by Vasarhelyi and appears to have clearly passed a normative test based upon the applications done during the development process.

## TRAINING AND IMPLEMENTATION

The entire system is appropriate for use by knowledgeable individuals, who are themselves not subject matter experts. Basic training will be necessary on aspects of computer operation and on the animal science/nutrition information necessary to adequately interpret visual and other observations for data entry. The research team believes that a one day training session should be adequate in most circumstances.

Field implementation of the system can be carried out on the farm by such trained personnel with a portable microcomputer. Structured barn sheets (Appendix C) will aid in obtaining data during barn inspections. Experience indicates that an initial session acquiring general data at the farmstead followed by an inspection of the facilities and then a return for final processing works best. Depending on the size of the dairy operation, 2 to 4 hours should be adequate to complete the diagnostic analysis for most small and mid-sized dairies.

The software package resulting from this effort, using data for any dairy farm currently under an appropriate record keeping system, appears capable of providing advice that will assist in improving dairy herd management and improving herd efficiency when adopting new technology.

## Section IV

## CONCLUSIONS

DairyPert™ represents a unique attempt, by animal scientists and agricultural economists, to design an expert system that will be useful in identifying management strengths and weaknesses on the nation's dairy farms. It is unique in the breath of concerns covered by the knowledge base developed from the experience of experts, and in the depth to which issues are capable of being investigated by use of the system. The resulting computer software package is also unique in the flexibility it affords for future enhancements and for ease of use through the natural language input and output components.

Only field experience will ascertain if DairyPert™ develops into a useful tool for those interested in the long-run financial health and profitability of the nation's dairy operations. The numerous "experts" who contributed their knowledge and experience to the formulation of the system represent the best in modern day dairy management talent. Through the system, their composite expertise is now available to anyone with the time to undergo the training required to use the package. Thus, the system not only has the capability of providing excellent clues to various management problems, but it can also lead to the rapid spread of current scientific knowledge at low cost to the nation's dairy farm managers.

Despite the scope of system coverage, however, many areas of concern to management still need enhancement within the system. As a pioneering attempt at broad scale expert system development, this effort should be looked on as a framework upon which future system enhancements can be built. Often only experience with the system under field conditions will lead to identification of missing components or areas where additional "rules" need to be identified in order to provide better diagnostics of management problems. Application to the diverse dairy industry, with it's differences in geographic location, dairy herd size, type of physical housing used and feed rations formulated, will assist in the identification of those areas needing future enhancement.

Several areas where expert judgment lacks strong research backing have, however, already been identified. For example, although agricultural economists have long evaluated aggregated profitability of our dairy farms (Smith, et. al.), little research has taken place on the influence that individual management decisions or practices have on the bottom line. Implementation of suggestions for changes in management practices, forthcoming from a DairyPert™ evaluation, would be enhanced if they could be better prioritized, quantitatively, with respect to their individual and combined impact on profitability. As of now, only the "educated guesses" of farm management experts are available for fixing such priorities. To the extent possible, these judgements have been built into the current version of DairyPert™.

Another area where future research would be valuable in fine tuning suggestions from the system pertains to the use of amino acid fractions in the evaluation of feed rations. Clearly, understanding the implications of supplying these basic building blocks of nutrition would assist in providing improved ration evaluations and in optimizing rations for obtaining a given level of production at least cost. Although research work is currently underway on this topic (Fox), it is still premature to modify the system's nutrition model in order to incorporate such cutting edge concepts.

A third area which we need to understand better as milk production levels per cow rise with the application of new technology is that of cow behavior. Reducing stress levels on individual animals will clearly be an important aspect of obtaining maximum production in the future. What does this mean in terms of housing practices, cow handling, environmental conditions, and milking frequency; to name but a few areas of concern? Additional field research will need to be incorporated into the system on these topics as experience is gained.

These and other areas of concern will ensure that a diagnostic method like that discussed above will be a constantly evolving tool that will continue to need enhancement with experience and new developments. Failure to do so will ensure that it's half-life will make it increasingly less relevant with each passing year.

However, an exciting option for future system development rests not so much on enhancements aimed at developing an improved diagnostic tool, but on the incorporation of an expert system, building on one similar to that specified here, into a network of real-time sensors and control devices designed to implement a computer-integrated dairy operation. Sensors monitoring animals, building and equipment can transmit information required for operational and tactical decision making to microprocessors and computers. This can provide information on the biological, physical, and chemical status of numerous factors important to efficient dairy farm operation; including animals, environmental conditions, people, processing and storage facilities, etc.

Sensor data, in conjunction with information from databases on important factors such as markets, the financial status of the business, historical trends, and management goals, can then be used to assist a manager in making real-time decisions concerning business operations (both minute by minute and longer-term). The manager would be aided in this endeavor by fully integrated software packages that use the real-time information in conjunction with expert systems and other economic optimization methods. In many instances, the system could implement management decisions without resort to human intervention by using devices controlled by the computer. Decision thresholds where human control would be required could be predetermined in accordance with the needs of the manager. New micro chip technology now allows a machine or device controller so small that it will fit any type of product or on individual animals and is smart enough to communicate and control other devices, flexible enough to communicate over standard media, and cheap enough that anyone can afford to use it.

Thus, the ability to centrally control devices based upon feedback from the environment is now in reach. Moreover, this control can be accomplished in a very precise manner. Add to this the ability to store large amounts of data and the possibility of improved learning from past experience and experimentation becomes increasingly viable.

To exploit these potentials, a number of hardware and software components must be integrated with expert system technology. Dairy farming is particularly well suited to developments of this type because it is labor intensive with numerous biological and physical processes that need to be monitored and controlled on a regular basis. Integrated data-acquisition systems can monitor animal performance automatically thereby freeing the manager from the drudgery of data collection and allowing him/her to spend more time analyzing the performance and evaluating the impact of management changes on a timely basis.

This, then, may be the shape of the future for progressive dairy operations. The expert system developed here is only a first, small step in that direction.

## REFERENCES


Albright, J. L., et al. 1988. "Guidelines for dairy cattle husbandry" in *Guide for the Care and use of Agricultural Animals in Agricultural Research and Teaching*. S. E. Curtis, ed. First Edition, pp. 28-32.

Albright, J. L., 1983. "Putting together the facility, the worker, and the cow." *Proceedings from the Second National Dairy Housing Conference*. Madison, WI., p. 15.

Albright, J. L., 1982. "Status of animal welfare awareness of producers with emphasis on direction of animal welfare research in the future." *Journal of Dairy Science*, 66:2208.

Albright, J. L., 1981. "Grooving fifteen year old concrete improved footing." *Hoards Dairyman*, Vol. 125, p. 241.

Albright, J. L., 1980. "We saved cows by grooving concrete." *Hoards Dairyman*, Vol. 125, p. 744.

Arave, C. W. and Albright, J. L., 1976. "Social rank and physiological traits of dairy cows as influenced by changing group membership." *Journal of Dairy Science*, 59:974.

Bauman, D. E.. *et al.* 1985. "Responses of high producing dairy cows to long term treatment with pituitary and recombinant somatotropin." *Journal of Dairy Science.*, 68:1352

Bickert, W. G., 1990. "Feed manger and barrier design." *Proceedings from Dairy Feeding Systems Symposium.* Harrisburg, PA. Northeast Regional Agricultural Engineering Service Publication No. 38, p. 199.

Coppack, C. E. *et. al.*, 1974. "Effect of dry period length on holstein milk production and selected disorders of parturition." *Journal of Dairy Science*, 57:712.

*Dairy Freestall Housing Symposium Proceedings*, 1986. Harrisburg, PA. Northeast Regional Agricultural Engineering Service Publication No. 24.

Dias, F. N. and Allaire, F. R., 1982. "Dry period to maximize milk production over two consecutive lactations." *Journal of Dairy Science*, 65:136.

Ferguson, James, June 1989. Personal interviews and transcript of same. University of Pennsylvania.

Ferreira, Leslie, April 1989. Personal interview and transcript of same. California Polytechnic State University.

Fox, D. G., *et al.* 1990. *The cornell net carbohydrate and protein system for evaluating cattle diets.* Cornell University Agricultural Exp. Station Bulletin No. 34.

Fox. D. G. Personal communication.

Hill, B. L.*et. al.* , 1973. The effect of two different freestall housing systems upon milk production, milk quality, health and behavior of dairy cows. *Journal of Dairy Science,* 56:688, Suppl. 1.

Irish, W. W. and Merrill, W. G., 1986. "How we would design freestalls." *Hoards Dairyman,* Vol. 131, p.14.

Kalter, R. J. 1989. "Animal biotechnology: potential socio-economic impacts." *Proceedings of the Seventh International Conference on Production Disease in Farm Animals,* Ithaca, NY. Proceedings.

R. J. Kalter, R. J., and Milligan, R. A. 1989. "Emerging agricultural technologies: economic and policy implications for animal production." *Agricultural biotechnology.* National Academy of Sciences.

Knoblauch, Wayne, September 1989. Personal interview and transcript of same. Cornell University.

Kutches, Alex, April 1989. Personal interview and transcript of same. O. H. Kruse Grain & Milling Co.

Longhouse, A. D. and Porterfield, I. D., 1954. *Dairy cows need larger stalls.* West Virginia Agricultural Experiment Station Circular 91.

Masuch, M., ed., 1990. *Organization, management, and expert systems: models of automated reasoning* . W. De Gruyter: Berlin, New York.

Merrill, William, June 1989. Personal interview and transcript of same. Cornell University.

Metz, J. H. M., 1984. "Space requirements for cattle." *International Congress of Applied Ethology of Farm Animals.* The University of Kiel, Federal Republic of Germany.

Milligan, Robert, April 1989. Personal interview and transcript of same. Cornell University.

National Research Council, 1989. *Nutrient requirements of dairy cattle, 6th rev. ed.* National Academy of Sciences, Washington, D. C.

Neuron Data, 1988. *Nexpert object fundamentals.* Palo Alto, CA.

Neuron Data, 1991. *Nexpert object: functional description and user's guide.* Palo Alto, CA.

Nocek, J. E. and Russell, J. B., 1988. "Protein and energy as an integrated system, relationship of ruminal potein and carbohydrate availability to microbial systhesis and milk pproduction." *Journal of Dairy Science*, 71:2070.

**Penn State Reference Manual**

Russell J. B., *et. al.*, 1983. "Effect of carbohydrate limitation on degradation and utilization of casein by mixed rumen bacteria." *Journal of Dairy Science*, 66:763.

Schwab, C., 1989. Personal communication.

Skidmore, A. L. 1990. Development of a simulation model to evaluate effectiveness of dairy herd management. Ph.D Thesis, Cornell University, Ithaca, New York.

Slenning, B. D. *et. al.* , 1985. *An approach to scoring dairy management: a manual of technique.* Dairy Arts & Communication, Waunakee, Wisconsin.

Smith, S. F. *et. al.*, 1990. *Dairy Farm Management: Business Summary New York 1989.* Dept. of Agr. Econ., Cornell University, Ithaca, NY.

Sniffen, Charles, May-June 1989. Personal interview and transcript of same. Micigan State University.

Spike, Thomas, July 1990. Personal interview and transcript of same. Eli Lilly and Company.

The Pennsylvania State University, 1980. *Dairy reference manual.* College of Agriculture, State College, Pa. Second Edition.

Vasarhelyi, M. A., 1988. *Artificial intelligence in accounting and auditing.* Markus Wiener Publishing, Inc., New York, New York.

Weaver, Leon, April 1989. Personal interview and transcript of same. University of California - Davis/Tulare.

Wierenga, H. K., 1984. "The effect of reduced space in cubicle stalls on dairy cows." *International Congress of Applied Ethology of Farm Animals.* The University of Kiel, Federal Republic of Germany.

## APPENDIX A

## DairyPert™ INSTRUCTIONS

## for

## IBM Compatible Computers Using Windows 3.0

The purpose of these instructions is to provide information on the set-up, operation and use of an expert system (DairyPert™) for diagnosing management problems on dairy farms. You will receive a set of three (3) floppy diskettes containing the RunTime version of DairyPert™ and associated hardware.

The instructions provided here refer to the version of the system configured to run under the Windows 3.0 for IBM compatible computers using the 80386 or newer processing unit. For other operating systems, you will need to obtain a version appropriate to your computer environment (DOS or Apple Macintosh). Results will be identical when using these other operating systems, but hardware/software requirements will obviously differ and the setup procedure will correspond to the operating system being used. The IBM Windows 3.0 procedures are included in this monograph because it will likely be the most popular operating environment within which the system is utilized. If you plan to use one of the other operating systems, complete installation instructions, program diskettes and operating methods are available from the authors.

The remainder of these instructions are divided into three sections: hardware/software requirements, RunTime installation, and using DairyPert™ RunTime.

### HARDWARE/SOFTWARE REQUIREMENTS

This DairyPert™ version requires the following computer configuration:

A. IBM compatible personal computer (with 80386 CPU);

B. A math co-processor chip is optional, but desirable;

C. Four megabytes of RAM memory;

D. A hard disk (with at least 5 megabytes of available space free);

E. A mouse (optional);

F. A VGA monitor is preferred (an EGA screen may be used);

G. Sentinel hardware lock (included with DairyPert™ package);

H. Windows 3.0;

I. Microsoft Excel 3.0;

J. Installation of DairyPert™ runtime software .

The hardware lock protects the RunTime version of the expert system from being used on more than one machine at a time. It is required by our licensing arrangement with Neuron Data for the expert system RunTime packages. Microsoft Excel is required to run the nutrition model component of the overall expert system. Excel 3.0 is required to operate under Windows 3.0. FoxPro database management software is also used by DairyPert™, but a runtime version is included with the system.

## RUNTIME INSTALLATION

The software included in the package accompanying these instructions includes a number of files pertinent to the four main modules making up the overall DairyPert™ system. These modules include input, nutrition model, core expert system, and output or results. Table A-1 lists the file names and types for each module and indicates on which disk they reside.

First, create a new subdirectory to which all of these files can be transferred. To do so, follow the instructions below.

After booting your system and moving to the C: drive, type:

**CD** *{Return}*

**MD\DPERT1** *{Return}*

**CD\DPERT1** *{Return}*

This creates a subdirectory entitled DPERT1 in the root directory into which the files present on all three floppy disks will be transferred. That sub-directory is then made active. NOTE: **These steps must be followed exactly or the proper paths for system execution will not be found by the system. Note further that the installation must take place on the C: drive to work properly.**

Starting with Disk 1 from the package, insert all the disks sequentially into your floppy drive and type:

**COPY [floppy drive designate]:*.*** *{Return}*

This will copy all the files from each floppy disk to the RunTime subdirectory on your hard drive. Often the floppy drive is A: so that the command will read: **COPY A:*.*** *{Return}*. However, you may have a different designation for the appropriate floppy drive. After completing this transfer, check the contents of the subdirectory against the files listed in Table A-1 to insure that all the transfers have taken place successfully.

Next, copy the file DairyPert.GRP into the subdirectory of your system that contains the Microsoft Windows software (this subdirectory is usually called Windows). Do so by typing:

CD\WINDOWS *{Return}*

COPY\DPERT1\DairyPert.GRP *{Return}*

This will copy a file that sets-up a Group Window under Windows for DairyPert™. When Windows is started, this window will automatically open and include the icons representing the runtime system. All directory pathways are also preset by this file. **This step and the accompanying files assume that your Windows 3.0 software is located in a subdirectory named WINDOWS. If this is not the case, you should rename the subdirectory to correspond.** ***Failure to do so will result in incorrect path names and will render your DairyPert™ inoperable unless all pathways are modified.***

The entire set of files necessary to run the model will consume under 3.5 megabytes of hard disk space (excluding the Excel.Exe file). Note that the worksheet files pertinent to the Excel nutrition module have been loaded by the above procedure into the **DPERT1** subdirectory. However, the pathways assume that Excel.Exe (the Excel program file) resides in a subdirectory entitled "**Excel**." If this is not the case, you will need to adjust the pathways to accommodate your own hierarchical file order. That is, the pathways established as part of the Group Window for DairyPert™ will need to be modified. Consult your Windows manuals for instructions if you are not familiar with this procedure. Use of the expert system will be greatly simplified if all relevant programs and files are organized in the above manner.

You will also need to ensure the following:

A. **Config.sys**, in the root directory, should include:

files = 30
buffers = 30

B. **Autoexec.bat**, in the root directory, should include:

PATH C:\DPERT1

**Note: At this point be sure that you have installed the Sentinel hardware key or lock on a parallel port at the back of your computer.**

## USING DairyPert™

To use DairyPert™, the four modules (Input or Start, Nutrition, Core Expert System and Results) are run sequentially. The Nutrition and Core Expert System modules are linked under Windows 3.0 and will run automatically after starting the Nutrition portion of the system.

<u>Input (START) Module</u>: To initiate a DairyPert™ session (an original diagnosis of a farm operation), go to the Windows subdirectory, start windows by typing **WIN**, and bring to the foreground the **DairyPert** group window by clicking on it (if this is not already the active window). Then merely double click on the DOS-**START** icon to begin a session.

*NOTE: Make sure Windows 3.0 is started in enhanced mode. This should be automatic if you have a computer with a 80386 CPU and have configured your start-up files correctly, as per Windows setup instructions. You can verify that Windows Enhanced is operating by opening the HELP pull-down menu of the Program Manager and clicking on the "About Program Manager..." item. If Windows Enhanced is not indicated, stop and refer to your Windows 3.0 manuals for advice on how to properly configure your system.*

Double clicking on DOS-**START** will invoke operation of the database manager (FoxPro) used for inputting the information required to run the nutrition and core expert system modules. You should refer to the barn sheets furnished as part of the runtime package. Make copies of these barn sheets for use during the "farm visit." All the data requested by these barn sheets will be required by the input routine. Note that the questions that will be asked by the computer follow exactly the organization of the barn sheets. Any time you desire to exit the program, depress the Escape key once and hit the Cancel button when it appears on the window at the bottom of the screen. However, exiting the program prior to completion of an entry session will result in all previously entered data being lost when the input module is restarted. No mechanism currently exists for partial data entry, system shut down, and restarting entry at the point where shut down occurred.

> *NOTE: Certain questions contained on the barn sheets will be skipped by the computer since it "knows" that the question will not be relevant in the circumstances being addressed. These same questions should not be answered on the barn sheets if they are completed properly.*

> NOTE: The DairyPert™ data entry module clears a number of database files (from previous sessions) and reloads these files with the data for the farm under consideration. These files include Chemical.dbf, Chemical.csv, Pens.dbf, Penfeeds.dbf, Penfeeds.csv, Nvars.dbf, and Pentotal.dbf. These files are necessary to complete execution of the second and third modules of the system (the nutrition model using an Excel spreadsheet program and the core expert system).

> ***Consequently, if you desire to retain this information for future use, these files should be <u>copied</u> to a separate subdirectory before beginning a session for a new farm (we suggest setting up this subdirectory with the name of the farm in question). Do not erase these files from the DPERT1 subdirectory - the system will automatically empty the preexisting files before starting a new session and the lack of an appropriate file name will cause the application to terminate.***

The DairyPert™ entry program consists of a number of entry screens with specific questions.

1. Several screens of general information about herd production, number of physical pens or enclosures, number of animals per enclosure and type of enclosure are asked first.

2. Then, a set of screens requests information on physical facilities pertaining to each pen or enclosure. These screens repeat (with some variation for each type of pen - corral, freestall, stanchion) for each enclosure indicated previously.

3. Next, information pertinent to evaluating rations and feeding characteristics is requested. These screens repeat for each physiological group in each enclosure and, in turn, for

each enclosure. The physiological groups include nine milk cow units (early, mid-, and late lactation first calf heifers, second calf heifers and third plus calf cows), a close-up and regular group of dry cows, a close-up and regular group of bred heifers, and young stock over 400 pounds in weight.

4. Finally, sets of screens dealing with reproduction and general dairy management questions are displayed. Neither of these two sets of screens repeats since they request general information applicable to the entire herd and not data pertinent to a specific physical enclosure or physiological group of animals.

In each case, the top of the screen clearly indicates the focus by displaying the type of information being requested and, if that information pertains to an enclosure, the pen number and/or pen name under consideration.

The program permits incorrect entries to be changed in several ways:

1. One can merely backspace (or use the mouse to change the location of the cursor) to an appropriate location on a screen and make a correction.

2. If an entry has been incorrectly made on a given screen, continue making entries until the bottom of the screen is reached and answer NO to the question "Are these values correct?". This will move the entry cursor to the top of the screen and allow changes to be made in any of the entries present using the TAB or Return key to space down through the screen. Previously entered values will not be erased by this process unless new information is typed at a cursor location.

3. If an incorrect entry is discovered after leaving an entry screen, continue data entry through the subsequent screens until the end of an entry module is reached. There are four such locations within the entry program. One at the end of questions pertaining to each physical enclosure, one at the end of questions pertaining to each ration, one at the end of questions pertaining to reproduction, and one at the end of questions pertaining to general management. Each of these locations is clearly identified by a window. At any of these locations, answering NO to the question "Are these values correct?" at the bottom of the screen will recycle the program through all the previous screens pertaining to the topic under consideration. Keying "Page Down" will allow rapid

movement through a set of screens to reach the question(s) that need to be corrected.

If errors are discovered after leaving a given entry module, **corrections cannot be made at this time.** One will need to start the entry process over. Future versions of the program will have a "restart" capability to permit data changes after completion of the entire entry routine or to change data items necessary to permit running the model on a "what if" basis.

Once the input portion of the process has been completed, proceed to run the nutrition and expert system models by following the instructions below.

<u>Nutrition and Core Expert System Modules</u>: Both the nutrition and core expert system modules use data from the input routine to develop conclusions concerning the farm under review. Thus, the input module **must** be completed in full before attempting to continue.

Assuming that data entry has been completed, start the analytical process by double clicking on the **ANALYSIS** icon contained in the DairyPert Group Window. This will initially invoke operation of the Excel based nutrition model, designed to facilitate accurate and appropriate ration analyses, and will then automatically open and run the expert system knowledge base.

The first screen that you will see appear is titled "OPTIONS.XLS." There are four options on this control screen. Each of the four options - New Feeds, Combined Feeds, Evaluate Rations, and Quit Excel - will be explained in detail below.

<u>New Feeds</u>: The New Feed section allows the user to input feed ingredients that are not contained in the existing Feed Library. The current Feed Library content is listed on the barn sheets and is made-up of ingredients whose chemical aspects have been characterized by the National Research Council (NRC).

Entry of new feed ingredients, and their chemical composition values, occurs through the New Feed screen using a unique identification number. There is also an option for saving these feeds to the Feed Library for continuing use on other dairies. Otherwise, none of the new feeds entered will be saved when the current session is over.

Information on new feeds is obtained from the barn sheets filled out during the farm inspection. When detailing the various rations, use the barn sheets to enter information for each new feed under a selected identification number. Regardless of the type of ingredient (concentrate, forage or mineral), this entry takes place under the "Forage" ingredient entry section and screen. A given identification number can be used with more than one ration if the ingredient is present. The model will automatically select the proper ration ingredients from the Library or the entry of New Feeds as it analyzes each ration specified. **A chemical analysis for a new feed cannot be entered through the "Input Module," however. These analyses must be entered as part of the new feed entry process.**

To initiate a new feeds entry session, follow the instructions at the top of the Options Screen by typing CRTL + b. This will bring up the new feeds entry screen. Similarly, follow the instructions at the top of that screen to complete the new feeds entry process.

<u>Combine Feeds</u>: The nutrition module does not allow for more than nine (9) feed ingredients (forages and concentrates) to be present in a ration at one time. The ration evaluation model will only handle nine feeds because of the formula size limitation for spreadsheet cells. This, however, may be inadequate in some situations. The "Combine Feeds" option permits this constraint to be relaxed. If more than nine feeds are present in a ration, some can be combined to meet the restriction. The instructions for how to combine feeds are contained on the barn sheets. No more than three (3) feed ingredients can be combined into a "combined feed." However, up to fifteen (15) "combined feeds" can be present in the feed library. The Combine Feeds option takes a weighted average of the selected feeds for all the chemical and other values needed in the evaluation model. Each Combined Feed has a unique number and those numbers and ingredient amounts should be entered beforehand in the "Input Module" of the system under the "Forage" ingredient entry screen. **A chemical analysis for a combined feed cannot be entered through the "Input Module," however. These analyses must be entered as part of the combined feed entry Excel spreadsheet.**

To initiate a combined feeds entry session, follow the instructions at the top of the Options Screen by typing CRTL + d. This will bring up the combined feeds entry screen. Similarly follow the instructions at the top of that screen to complete the combined feeds entry process.

<u>Evaluation of the Ration</u>: Information, if any, from "New Feeds" and "Combined Feeds" is used, along with regular ration information obtained from the "Input Module" and contained in the Penfeeds.csv and Chemical.csv files, as data for the nutrition model. The spreadsheet evaluates each of the rations based on this data and stores the results for use by the expert system module in a file named RESULTS.DBF. All three files must be present in the DPERT1 sub-directory before the ration model will function.

To initiate the ration(s) evaluation, follow the instructions at the top of the Options Screen by typing CRTL + a. This will automatically start the evaluation(s) and at their completion turn control over to the expert system.

At the end of the expert system analysis, control is returned to the Options Screen. Depending on the number of pens and physiological groups for which rations are being evaluated, ration evaluation could take from three minutes to more than a half hour. A "Please Wait" screen appears on the monitor while solutions are in process. Solution of the Expert System will normally take from two to ten minutes. During solution a number of windows will appear and disappear from your screen indicating that data is being retrieved or files are being written. During the bulk of the solution time, a window labeled "SESSION CONTROL" will be present on your monitor.

> ***In either the Combined Feed section or the Ration Evaluation section, an error message may appear entitled: Can't Resolve Circular References." If that should happen, either press Enter or click on the OK button. No error is present, since the program will handle the circular references.***

Quit Excel: The last option is "Quit Excel." This will close all open files, saving none of them and cause Excel to terminate operation. To quit, follow the instructions at the top of the Options Screen by typing CRTL + q.

> **Note: If the expert system windows do not appear, you have probably not installed the Sentinel hardware key or lock on a parallel port at the back of your computer.**

Results Module: The nutrition model solution is utilized by the knowledge base and expert system module along with other input data to reach numerous conclusions about management of the dairy farm in question. To review and/or print the conclusions of the expert system session and possible actions that could be taken, double click on **DOS-RESULTS** in the DairyPert Group Window. This will retrieve the database program and solution answer files for screen and/or printer display. The help screens that automatically pop-up as this module begins to run are self-explanatory guides to its use. If screens come up in reverse video, they can usually be changed by holding down the CTRL and ALT keys while simultaneously pressing the BkSp key.

If at any time you desire to exit the program, depress the Escape key once and hit the Cancel button when it appears on the window at the bottom of the screen.

TABLE A-1

**DairyPert™ EXPERT SYSTEM FILES**

| **DISK 1** | **Input Module** |
|---|---|
| CHEMICAL.CSV | Ration chemical analysis data [Comma delimited for Excel input] |
| CHEMICAL.DBF | Same as above in DBase III format |
| DPERT4.FXP | Compiled DairyPert™ main program |
| FEEDINDX.IDX | Index file for NRC feed ingredient library |
| FEEDLIB1.DBF | DBase III format feed ingredient data base for use with DairyPert™ |
| FEEDS.DBF | DBase III format feed ingredient data base for use with DairyPert™ entry screen |
| FOXPRORT.EXE | RunTime data base program |
| FOXPRORT.OVL | RunTime overlay file |
| FOXPRORT.RSC | RunTime strings file |
| FOXUSER.DBF | RunTime resources file |
| FOXUSER.FPT | RunTime resources memo file |
| GENVARS.MEM | DairyPert™ Memory variables |
| NEWVARS.MEM | DairyPert™ memory Variables |
| NEXTVARS.MEM | DairyPert™ memory variables |
| NG1INIT.FXP | Compiled program file |
| NGINIT.FXP | Compiled program file |
| NVARS.DBF | General input data base |
| PENFEEDS.CSV | Feed rations data base [Comma delimited for Excel input] |
| PENFEEDS.DBF | Same as above in DBase III format |
| PENS.DBF | Pen data in DBase III file format |
| PENTOTAL.DBF | Pen data in DBase III file format |
| SCRNS2.FXP | Compiled program file |

TABLE A-1 - CONTINUED

| | |
|---|---|
| **DISK 2** | **NUTRITION MODULE** |
| CHEMANA.XLS | Excel spreadsheet for chemical analysis |
| CHEMICAL.XLM | Excel macro for changes in chemical analysis |
| CHEMICAL.XLS | Excel input spreadsheet for chemical analysis |
| CMBOWAIT.XLS | Wait screen for combination feeds spreadsheet |
| COMBINE.XLS | Excel spreadsheet for combining feeds |
| COMBNTR.XLM | Excel macro for combining feeds |
| CONTROL.XLW | Excel Control Screen workspace |
| COWDT2.XLS | Nutrition model spreadsheet |
| COWWAIT.XLS | Wait screen for nutrition model |
| DEFAULT.XLS | Wait screen |
| FEEDLIB1.XLS | NRC feed library and chemical values |
| MACRO2.XLM | Excel macro for nutrition program |
| NEWFEED.XLM | Excel macro for new feed entry |
| NEWFEED.XLS | Excel spreadsheet for new feed entry |
| NWFDSAVE.XLS | Wait screen for new feeds entry routine |
| NWFDWAIT.XLS | Wait screen for new feeds entry routine |
| OPTIONS.XLS | Excel spreadsheet for control options |
| RESULTS.DBF | Nutrition spreadsheet results DBase III file |
| **DISK 3** | **KNOWLEDGE BASE MODULE** |
| ELANCO87.CKB | Compiled knowledge base |
| ELANCO.RTD | Expert system batch file |
| NEXPERT.DAT | NEXPERT database file |
| NEXPERT.EXE | MS/Windows NEXPERT DDE server |
| RESULTS1.DBF | DBASE III format expert system results file |
| RESULTS2.DBF | DBASE III format expert system results file |
| DAIRYPERT.GRP. | Windows3 group window format file |
| **DISK 2** | **RESULTS MODULE** |
| DIAGNOST.DBF | DBase III format diagnostic advice file |
| DIAGNOST.FPT | Memo file for DIAGNOST.DBF |
| REMEDIAL.FXP | Compiled data base program for RESULTS advice |
| REMS2.FXP | Procedures file for above |
| RULEINDX.IDX | Index file for DIAGNOST.DBF |

APPENDIX B

DairyPert™ Rule References

| AREA | SUB-AREAS | DIVISIONS | REFERENCE |
|---|---|---|---|
| **Nutrition** | | | |
| | General | | Sniffen, 1990 |
| | Feed Quality | | |
| | | General | Sniffen, 1990 |
| | | Ration Fiber | Sniffen, 1990 |
| | | Ration Energy | Sniffen, 1990 |
| | | Ration Degradable Protein | Sniffen, 1990<br>Schwab, 1989 |
| | | Ration Soluble Protein | Sniffen, 1990 |
| | | Fiber Digestibility | Nocek et. al., 1988<br>Russell, et. al., 1983 |
| | | Starch Digestibility | Russell, et. al., 1983<br>Nocek et. al., 1988 |
| | | Trace Minerals | Sniffen, 1990 |
| | Feed Quantity | | Albright, et. al., 1988<br>Sniffen, 1990<br>Slenning, et. al., 1985 |
| | Dry Cow Ration | | Sniffen, 1990 |
| | Milk Cow Ration | | |
| | | General | Sniffen, 1990 |
| | | Dry Matter Intake | Sniffen, 1990 |
| | | Sequence of Feeding | Sniffen, 1990 |
| | Minerals | | Sniffen, 1990 |
| **Physical Facilities** | | | |
| | General | | Ferreira, 1990<br>Weaver, 1990<br>Sniffen, 1990<br>Albright, et. al., 1988 |

Appendix B Continued

| | | | |
|---|---|---|---|
| | Bunk Space | | Bickert, 1990<br>Albright, 1982<br>Sniffen, 1990 |
| | Cow Comfort | | Albright, 1982<br>Albright, et. al., 1988<br>Arave, 1974<br>Metz, 1984<br>Wierenga, 1984<br>Albright, 1980<br>Albright, 1981<br>Albright, 1983<br>Slenning, et. al., 1985<br>Irish, et. al., 1986<br>Longhouse, 1954<br>Dairy F. S. S., 1986<br>Sniffen, 1990<br>Hill, 1973 |
| | Facilities Management | | |
| | | Stall Maintenance | Albright, et. al., 1988 |
| | | Walking Ease | Albright, et. al., 1988<br>Sniffen, 1990 |
| | | Bedding | Albright, 1982<br>Sniffen, 1990 |
| | | Manger | Albright, et. al., 1988<br>Sniffen, 1990 |
| | Manger Access | | Sniffen, 1990 |
| | Ventilation | | Slenning, et. al., 1985 |
| | Water Quality | | Penn State Dairy Ref. Manual, 1980 |
| | Water Quantity | | Penn State Dairy Ref. Manual, 1980<br>Sniffen, 1990 |
| **Herd Health** | | | |
| | Feed Practice | | Ferguson, 1990<br>Sniffen, 1990 |
| | Sanitary Practice | | Ferguson, 1990 |

Appendix B Continued

| | | | |
|---|---|---|---|
| **Reproduction** | | | |
| | Cull Rate | | Ferguson, 1990 |
| | Retained Placenta | | Ferguson, 1990 |
| | Maternity Pen Management | | Ferguson, 1990 |
| | Pregnancy rate | | Ferguson, 1990 |
| | Heat Detection | | Ferguson, 1990 |
| | Early Breeding | | Ferguson, 1990 |
| | Dry Period | | Dias, et. al., 1982<br>Coppock, et. al., 1974 |
| **Replacement** | | | |
| | General | | Ferguson, 1990<br>Sniffen, 1990 |
| | Young Stock Management | | Ferguson, 1990<br>Sniffen, 1990 |
| **Milking Practices** | | | Merrill, 1990 |
| **Herd Management Ability** | | | Sniffen, 1990<br>Ferreira, 1990<br>Weaver, 1990<br>Spike, 1990<br>Slenning, et. al., 1985 |
| **Economics** | | | |
| | Cash Flow | | Knoblauch, 1990 |
| | Cost Control | | Knoblauch, 1990 |
| | Debt | | Knoblauch, 1990 |
| | Profitability | | Knoblauch, 1990 |
| | Milk Production Rate | | Knoblauch, 1990 |
| | Herd Size | | Knoblauch, 1990 |
| | Labor Efficiency | | Knoblauch, 1990 |
| | Risk | | Milligan, 1990 |

# APPENDIX C

## DairyPert™ Barn Information Sheets and Associated Instructions

Barn information sheets serve as forms to facilitate data capture during the farm visit. The sheets are structured so that the information collected can be entered directly into the computer. This approach has the benefit of easing the data capture task, compared to direct computer entry during the barn-walk-through, of creating a hard copy of the information collected for future update, and of appearing less structured and more informal to the dairyman.

After the preliminary pages, the barn sheets are labeled to correspond to the computer entry screens used later (i.e., SCREEN 1 - PHYSICAL FACILITIES, SCREEN 2 - NUTRITION, etc.). Questions that are indented and printed in italics should be answered only if the question immediately preceding them is answered as "True." During computer entry, such dependent questions will not be shown on the screen if the answer to the initial question is "False."

Since the barn sheets are organized to facilitate entry of information into the computer, the sequence of pages should not be altered from that provided in the forms following these instructions! Note, however, that three different entry forms are provided for obtaining information on physical facilities (Section 2). Only one form for each pen or enclosure should be used. The choice depends on whether the pen or enclosure is a corral/pasture, a freestall (including those with an exercise yard), or a stanchion facility. Because DairyPert™ evaluates each enclosure or pen individually, a different entry sheet is needed to elicit the information appropriate to each type of facility. If a given enclosure is of mixed type, then use the entry form which most closely approximates the predominant type of housing being used at the time of the evaluation.

The remainder of this Appendix is divided into discussions of the various sections composing the barn information sheets. A general overview of each section is provided and answers to possible questions about definitions, entry format and other procedures within the section are provided. This Appendix should be used in conjunction with Appendix A when entering information into the computer through the data entry module.

### SECTION I

The first section of the Barn Information Sheets requests general data such as farm name, operator(s) name, address, telephone number, feed dealer's name, veterinarian's name, and nutrition consultant's name. These items are not entered into the computer data bank, but are requested as backup information which could be useful at a later point. Then general herd information is requested. This includes the rolling herd average, the number of pens or enclosures making-up the operation, the physiologic groupings within pens, and the size of each group. This information is needed for computer entry and the questions should be self-explanatory.

Page 2 of the entry forms contains a table requesting detailed information on each pen. In the appropriate boxes enter the pen numbers or names used by the operator to distinguish animal groupings, select each pen's housing type, mark as "true" each physiologic grouping present in each pen, and provide the number of milk cows, dry cows, bred heifers and young stock present in each enclosure. The total number of animals present in each pen will automatically be calculated during computer entry procedure and need not be entered except as a cross check for accuracy.

SECTION II

The second section requests data on the physical aspects of animal housing. Select the appropriate Section II entry forms - corral, freestall, or stanchion - to match the pen types specified in Section 1. The information requested must be entered for each physical pen (up to eleven [11] can be entered on a single barn sheet *for a given type of housing*). Use additional entry sheets if the number of similar-type pens exceeds eleven.

On the entry forms, the check marks to the left of the question indicate the physiologic animal groups to which the question applies (M = milk cows; D = dry cows; B = Bred Heifers; and Y = Young Stock over 400 pounds in weight). If a check mark is present under one or more of these headings, then the question to the right should be answered for the pen(s) containing animals of that physiologic group. For pens containing physiologic animal groups that are not checked, the associated question need not be answered.

Several questions in this section may require some additional explanation. These include:

1. Pen length and pen width should be entered in feet. In a corral environment, acreage measures can be converted to feet by the rule that an acre equals 208.7 by 208.7 feet. For example, a 10 acre pasture or a 10 acre corral, would have the dimensions of 2,087 feet by 2,087 feet. These two questions are used by the computer system to calculate space-per-cow in square feet per cow.

2. For corral and freestall facilities, physical barriers to bunk access refers to anything that might have been

placed in front of or alongside a bunk or anything that might restrict access to a bunk. For instance, a skid loader or a feed wagon parked against the bunk or material that is piled along the side of a bunk would reduce access.

3. Also, for corral and freestall facilities, the question on square footage of shade per cow may be difficult to estimate under some circumstances. For example, if shade is provided by trees, then an estimate will be necessary. To calculate the square footage of shade from a tree assume that the area providing the shade is circular in circumference with a radius equal to the distance from the trunk to the outermost branches. Then multiply the radius (measured in feet) by itself and the result by 3.14 ($\pi$). That will give the area of shade provided by a tree, or at least a rough estimate. Don't forget to enter this value on a per cow basis.

4. The question concerning whether it takes longer than thirty seconds to fill a two gallon bucket at times of peak water demand is a means of measuring the adequacy of water pressure in the system supplying the facility. It is used in lieu of a pressure gauge to evaluate water supply.

5. The two questions on whether summer and winter ventilation are adequate for the facility anticipate a subjective answer. The evaluator will need to use his or her judgment and experience, as well as the discussion with the dairyman to answer these questions.

## SECTION III

Section III requests ration information for each physiologic group present in each pen or enclosure identified in Section I. Again, to the left of the questions on the entry forms, check marks indicate the physiologic animal groups to which a question applies (M = milk cows; D = dry cows; B = Bred Heifers; and Y = Young Stock over 400 pounds in weight). If a check mark is present under one or more of these headings, then the question to the right should be answered for the pen(s) containing animals of that physiologic group. For pens containing physiologic animal groups that are not checked, the associated question need not be answered.

Remember, up to fourteen physiologic groups may be present in any physical pen or enclosure. The groups are:

A. Early 1st lactation cows;
B. Mid-1st lactation cows;

C. Late 1st lactation cows;
D. Early 2nd lactation cows;
E. Mid-2nd lactation cows;
F. Late 2nd lactation cows;
G. Early 3+ lactation cows;
H Mid-3+ lactation cows;
I. Late 3+ lactation cows;
J. Close up dry cows;
K. Other dry cows;
L. Close up bred heifers;
M. Other bred heifers; and
N. Young stock (over 400 lbs. of body weight).

Each group is evaluated as if they received a separate distinct ration. Even if the same ration is fed to each physiologic group within a pen, the computer will request the ration information by physiologic group and the information gathered by the barn information sheets needs to correspond to this format. That is, for the Section III entry sheets, the eleven locations provided for answers to each question refer to a single pen. Usually the number of physiologic groups will not exceed that number in a given facility. Thus, for Section III, it is suggested that one set of entry sheets be used for each physical pen or enclosure.

Note, however, that if one ration is fed to all the physiologic groups in a given pen, ration ingredient data will need to be entered into the computer only once. This is because the computer "remembers" the first entry and will apply it to subsequent physiologic groups if the evaluator requests.

**General Nutrition Issues**: The first entries deal with a series of questions concerning general nutrition, feed types, and feeding sequences. These are all self-explanatory with several possible exceptions. These include:

1. For the question dealing with whether animals in a pen are dewormed, answers may differ depending upon the geographical location of the farm as well as the deworming practices followed. For instance, in southern climates, where there is no winter kill of parasites, animals exposed to pasture some time during the year should be dewormed either four times a year, at the time of dry off, or at the time of calving. If one of those conditions is met, then the answer is true. In northern climates, where there is a winter kill of parasites, it is recommended that cattle be dewormed twice in the spring if they are exposed to pasture. If this recommendation is not followed, then the answer to the question is False.

2. The series of questions that relate to the types of feed fed and the sequence of feeding need to be answered with reference to each other. For instance, the question on whether corn silage is fed before hay crop silage only applies if both hay crop and corn silage are fed. On the computer input, the question will not appear unless this condition is met. The other feeding sequence questions are obviously related in a similar fashion.

3. On the question concerning whether or not the manure contains whole or partially digested kernels of corn, answer True if you can see corn in the manure. If you can see corn by using the toe test -- sticking you toe in a fresh pile -- also answer True. Only fresh piles that have been undisturbed are to be evaluated to differentiate corn that is passed through in the manure and that which may have been dropped in from either the bunk or other extraneous sources.

**Ration Ingredients**: After answering the initial nutrition questions, a work sheet is provided for listing the specific ingredients contained in the ration provided to each physiologic group in a pen. Up to nine different feed ingredients and eight different mineral ingredients can be specified for each ration.

**Combined Feeds**: If the total number of ingredients exceeds the number allowed, up to three ingredients can be combined into one entry by using one or more of the "combined feeds" entry locations listed under the forage section. To facilitate the combining of feeds, a -- Combined Feeds Worksheet -- is provided. The computer program will take the weighted average of the feeds to be combined and create one feed for each combination specified. It also allows for a chemical analysis for any of the feeds that are to being combined.

Each feed combination will have a unique index number similar to that assigned to the conventional feeds included in the feed library. Because combined feeds are weighted averages, changing the proportions of ingredients used will change the result. Thus, a new combined feed should be assigned if the same ingredients are used for another ration but the proportions fed change.

**New Feeds**: The ration ingredient section of the barn information sheets contains a list of feeds that are present in the computer library, along with a unique index number. If a particular feed is not included, then that feed is classified as a new feed and can be entered under that category in the forage section. Simply enter the new feed at that point and complete the "New Feed Worksheet" to facilitate the entry of information on the ingredient characteristics.

At the point of computer entry, a new feed can be saved in the feed library for future use by the system. For example, if there is a commercial feed that is used by several dairymen, saving the original entry would reduce the time requirements for data entry in future evaluations. To determine what new feeds are stored in feed library, start Excel and open the NEWFEED.XLS and the MACRO2.XLM file. Then, press Control-B and any saved new feeds will appear on the computer screen along with all the appropriate values that have been entered for those feeds. This list can be printed in the conventional manner for handy reference.

**Amount Fed/Chemical Analysis**: After selecting the various ingredients present in a given ration, information is requested on the amount fed or eaten by the animals (preferred, but usually not known), whether the amounts provided are calculated on a "dry matter" or "as fed" basis, and whether a chemical analysis on a feed ingredient has been obtained. If a chemical analysis is available, then an additional work sheet -- Chemical Analysis -- will need to be prepared.

**Minerals**: Up to eight different minerals can be entered under the mineral section. If the ration for a particular group is receiving more than eight minerals, then you must go through the same procedure in combining minerals as is done for combining feeds. If a mineral you are feeding is not contained in the Feed Library, then it will be classified as a new feed and can be entered under the mineral section as a new feed.

**Representative Animal/Environment**: Finally, after entering the ration information, a series of questions is asked to ascertain information relative to the representative or average, animal in the group being evaluated and the environmental conditions present in the pen (i.e., the average age and body weight, days pregnant, days in milk, production, average temperature and humidity, etc.). The responses to these questions are used to predict animal requirements and the ability of the ration to meet those requirements. Thus, accurate estimates are critical to the diagnostics that will be forthcoming from the evaluation system.

## SECTION IV

Section IV requests information on reproductive and maturity facilities. The questions in this section are self-explanatory.

SECTION V

Section V requests information on farm and dairy management practices. The answers to these questions are used, in part, to assist in the evaluation of an operator's management expertise. This data is, in turn, used to calibrate the results of the evaluation supplied to the dairyman and to better specify any suggestions for change in dairy practices.

This Section is divided into two parts. The first is a series of questions requiring direct discussion with the dairy operator or owner. The second contains questions that can be answered from observation by the evaluator during the farm inspection or from general discussions with the operator. Some of these latter questions may require a series of carefully planned questions to form appropriate subjective judgments.

All of the questions in Section V apply to the herd as a unit and not to individual physical enclosures or to physiological groups. In Part A, many of these questions are quite subjective. For instance, "Does the operator make extensive use of DHIA data?" Extensive use is not defined but is left to the judgment of the evaluator. Another example is the question "Are DHIA individual summary sheets, current tester's record, etc. largely consistent in the number of cows shown?" Again, the definition of consistency is left to the evaluator.

Several questions in this section may require some additional explanation. These include:

1. The question requesting information on when a veterinarian is called can be answered with up to three different responses. Respond by indicating all of the categories for which a veterinarian is used--for emergencies, for regular reproductive herd checks, and/or for regular consultations concerning total herd health. Regular consultations refers to when the veterinarian sits down with the management of the dairy at regular intervals, whatever that interval may be, to discuss herd health and management. It does not refer to the asking of general questions or consultations during reproductive exams or emergencies.

2. For financial questions, like those related to net farm income, farm debt/equity ratio, and cash flow coverage ratio, enter a zero if unknown or if the operator prefers not to reveal the proper values. The computer will consider a zero value as unknown and will eliminate related economic factors from consideration. Note,

however, that if this takes place the analysis provided will lack the scope that the system is capable of delivering.

3. Again, as stated earlier, Part B questions need to be answered either from direct observation during the farm visit or from, informal but directed, discussions with the dairymen. They should not be asked directly, since the objective is to determine what is actually happening on the operation and not what the operator believes the evaluator wants to hear. If observation is not sufficient to obtain the appropriate information, the use of leading questions may be helpful.

## WELCOME TO DAIRYPERT

DAIRYPERT is a computerized diagnostic tool designed to assist in evaluating your dairy herd management practices. Information about your farm is analyzed and the results used to provide guidance on improving profitability and to aid in making decisions about the adoption of new technologies such as bovine somatrotropin.

DAIRYPERT is based on the knowledge and practical experience of experts in dairy nutrition, physical facilities, reproduction, milking practices, herd health, management practices and economics. It was funded by Elanco Animal Health and Lilly Research Laboratories, Divisions of Eli Lilly and Company, and Cornell University.

## GENERAL HERD AND MANAGEMENT INFORMATION

We need to obtain basic information about your herd, its size, and how it is housed. Please enter the appropriate information below:

Rolling Herd Average (lbs.): ____________

Do you participate in DHIA? T/F ____________

Enter the total number of physical pens or contiguous animal groupings used to house this herd (including milk cows, dry cows, bred heifers and young stock over 400 lbs.). ____________

For each physical pen or contiquous animal grouping, enter the type of facility (corral, freestall, or stanchion), the physiological animal types housed and the total number of each major physiological type at the appropriate location on the next page. Space is provided for up to eleven (11) pens. If more are used, enter the data on a second worksheet.

Farm Information (not to be entered into the computer):

Farm Name ----------------------------------------

Operator(s) Name ----------------------------------------

Address ----------------------------------------

Phone ----------------------------------------

Feed Dealer ----------------------------------------

Veterinarian ----------------------------------------

Nutrition Consultant ----------------------------------------

| PEN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|

| GIVEN NAME OR # | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Corral/Pasture | | | | | | | | | | | |
| Freestall | | | | | | | | | | | |
| Stanchion/Tiestall | | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Early 1st Lac. Cows T/F | | | | | | | | | | | |
| Mid 1st Lac. Cows T/F | | | | | | | | | | | |
| Late 1st Lac. Cows T/F | | | | | | | | | | | |
| Early 2nd Lac. Cows T/F | | | | | | | | | | | |
| Mid 2nd Lac. Cows T/F | | | | | | | | | | | |
| Late 2nd Lac. Cows T/F | | | | | | | | | | | |
| Early 3+ Lac. Cows T/F | | | | | | | | | | | |
| Mid 3+ Lac. Cows T/F | | | | | | | | | | | |
| Late 3+ Lac. Cows T/F | | | | | | | | | | | |
| *TOTAL MILK COWS* | | | | | | | | | | | |
| Close-up Dry Cows T/F | | | | | | | | | | | |
| Other Dry Cows T/F | | | | | | | | | | | |
| *TOTAL DRY COWS* | | | | | | | | | | | |
| Close-up Bred Heifers T/F | | | | | | | | | | | |
| Other Bred Heifers T/F | | | | | | | | | | | |
| Young Stock > 400# T/F | | | | | | | | | | | |
| *TOTAL BRED HEIFERS -YOUNG STOCK* | | | | | | | | | | | |
| *GRAND TOTAL* | | | | | | | | | | | |

For each group of animals indicated previously, we need to obtain information on the physical aspects of the housing, on the animals themselves and on the feed rations used. We will begin with questions on each physical pen or facility and then proceed to the animals comprising each physiological type in each pen and their rations. Depending on whether the pen is a corral, freestall or stanchion facility, and the maturity of the animals in the pen, the questions will differ to some degree.

## SCREEN 1 - PHYSICAL FACILITIES
## CORRALS

| M | D | B | Y | PEN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | Can this pen's structure be closed on at least 3 sides year round? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Enter pen length: (ft.) [0.00] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Enter pen width: (ft.) [0.00] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is the yard surface concrete? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | *If yard surface is not concrete, what is the surface slope (percent) of the yard? [0.00]* | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | *If yard surface is not concrete, are there excessive mud conditions in this pen during any part of the year? [T/F]* | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Enter average bunk space per animal occupying this pen [i.e.. 2.5 ft.]. | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Are there any physical barriers to bunk access in this pen? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What percent of the manger bottom is rough for this pen? [0.00] | | | | | | | | | | | |
| ✓ | | | | Is this pen using an elevated bunk? [T/F] | | | | | | | | | | | |
| ✓ | | | | Enter the number of computer/magnetic feeders used. | | | | | | | | | | | |
| ✓ | | | | Enter the number of manger headlocks ? | | | | | | | | | | | |
| ✓ | | | | *If headlocks, are cows ever locked at bunk > .5 hrs.? [T/F]* | | | | | | | | | | | |

M = Milk Cow
D = Dry Cow
B = Bred Heifer
Y = Young Stock

## SCREEN 2 - PHYSICAL FACILITIES
## CORRALS

| M | D | B | Y | PEN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | What is the water tank capacity per animal in gallons for this pen? [0.00] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | How many linear feet of water trough space are available for this per [include both sides & ends of the trough if accessable]? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is the water tank in this pen ever empty? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Are the water troughs kept clean for animals in this pen? [T/F] | | | | | | | | | | | |
| ✓ | | | | Do the cows in this pen congregate at the waterer after milking? [T/F] | | | | | | | | | | | |
| ✓ | | | | Are water application devices (misters, etc.) used to cool the animals during hot periods of the year? [T/F] | | | | | | | | | | | |
| ✓ | | | | Is there adequate light in this pen for the animals to see clearly? [T/F] | | | | | | | | | | | |
| ✓ | | | | Are fans used to cool the animals in their pens or in the holding area? [T/F] | | | | | | | | | | | |
| ✓ | | | | Are shades furnished for the animals in this pen? [T/F] | | | | | | | | | | | |
| ✓ | | | | *If shade is furnished, is shading furnished over the mangers of this pen? [T/F]* | | | | | | | | | | | |
| ✓ | | | | *If shade is furnished, what is the square footage of shade per cow in this pen? [0.00]* | | | | | | | | | | | |

## SCREEN 3 - PHYSICAL FACILITIES
## CORRALS

| M | D | B | Y | PEN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | | | | Do the animals in this pen have difficulty walking due to manure, etc.? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | | | Does this pen contain areas which would harbor rodents and insects (piles of hay, slag, dirt, tires, trash, etc.)? [T/F] | | | | | | | | | | | |

## SCREEN 4- PHYSICAL FACILITIES
## CORRALS

| M | D | B | Y | PEN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | What is the source of water for this pen? [Deep Well (below rock)/ShallowWell/Surface] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the coliform count (in parts/100 ml.) of the water used in this pen (enter 0 if unknown)? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is the water supply to this pen saline? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the nitrate count (in parts/million) of the water used in this pen (enter 0 if unknown)? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Does it take longer than 30 seconds to fill a two-gallon bucket at times of peak demand (milking)? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is there adequate summer ventilation for this pen? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is there adequate winter ventilation for this pen? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is a strong smell of ammonia present in this pen during the summer? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is a strong smell of ammonia present in this pen during the winter? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the predominant breed of the animals in this pen? [Brown Swiss/ Holstein/Jersey/Guernsey/Ayrshire] | | | | | | | | | | | |

For each group of animals indicated previously, we need to obtain information on the physical aspects of the housing, on the animals themselves and on the feed rations used. We will begin with questions on each physical pen or facility and then proceed to the animals comprising each physiological type in each pen and their rations. Depending on whether the pen is a corral, freestall or stanchion facility, and the maturity of the animals in the pen, the questions will differ to some degree.

## SCREEN 1 - PHYSICAL FACILITIES
## FREESTALLS

| M | D | B | Y | PEN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | Can this pen's structure be closed on at least 3 sides year round? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | | | Enter pen length: (ft.) [0.00] | | | | | | | | | | | |
| ✓ | ✓ | | | Enter pen width: (ft.) [0.00] | | | | | | | | | | | |
| ✓ | ✓ | | | How many stalls are available for use by the animals in this pen? | | | | | | | | | | | |
| ✓ | ✓ | | | What is the average length (in feet) of stalls in this pen? [0.00] | | | | | | | | | | | |
| ✓ | ✓ | | | What is the average width (in feet) of stalls in this pen? [0.00] | | | | | | | | | | | |
| ✓ | ✓ | | | Indicate the nature of the stall surface's base [Wood/Concrete/Clay/Gravel] | | | | | | | | | | | |
| ✓ | ✓ | | | *If stall surface is clay or gravel what percent of the stalls in this pen are dug out? [0.00]* | | | | | | | | | | | |
| ✓ | ✓ | | | Do the animals in this group have an exercise yard? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | | | *Is the yard surface concrete? [T/F]* | | | | | | | | | | | |
| ✓ | ✓ | | | *If yard surface is not concrete, what is the surface slope (percent) of the yard? [0.00]* | | | | | | | | | | | |
| ✓ | ✓ | | | *If yard surface is not concrete, are there excessive mud conditions in this pen during any part of the year? [T/F]* | | | | | | | | | | | |

M = Milk Cow
D = Dry Cow
B = Bred Heifer
Y = Young Stock

## SCREEN 2- PHYSICAL FACILITIES
## FREESTALLS

| M | D | B | Y | PEN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | Enter average bunk space per animal occupying this pen [i.e.. 2.5 ft.]? | | | | | | | | | | | |
| ✓ | ✓ | | | Are there any physical barriers to bunk access in this pen? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | | | What percent of the manger bottom is rough for this pen? [0.00] | | | | | | | | | | | |
| ✓ | ✓ | | | Is the alley surface concrete? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | | | *If alley surface is concrete, is it grooved? [T/F]* | | | | | | | | | | | |
| ✓ | | | | Is this pen using an elevated bunk? [T/F] | | | | | | | | | | | |
| ✓ | | | | Enter number of computer/magnetic feeders used? | | | | | | | | | | | |
| ✓ | | | | Enter number of manger headlocks ? | | | | | | | | | | | |
| ✓ | | | | *If headlocks, are cows ever locked at bunk > .5 hrs.? [T/F]* | | | | | | | | | | | |

## SCREEN 3 - PHYSICAL FACILITIES
## FREESTALLS

| M | D | B | Y | PEN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | What is the water tank capacity per animal in gallons for this pen? [0.00] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | How many linear feet of water trough space are available for this per [include both sides & ends of the trough if accessable]? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is the water tank in this pen ever empty? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Are the water troughs kept clean for animals in this pen? [T/F] | | | | | | | | | | | |
| ✓ | | | | Do the cows in this pen congregate at the waterer after milking? [T/F] | | | | | | | | | | | |
| ✓ | | | | Are water application devices (misters, etc.) used to cool the animals during hot periods of the year? [T/F] | | | | | | | | | | | |
| ✓ | | | | Is there adequate light in this pen for the animals to see clearly? [T/F] | | | | | | | | | | | |
| ✓ | | | | Are fans used to cool the animals in their pens or in the holding area? [T/F] | | | | | | | | | | | |
| ✓ | | | | Are shades furnished for the animals in this pen? [T/F] | | | | | | | | | | | |
| ✓ | | | | *If shade is furnished, is shading furnished over the mangers of this pen? [T/F]* | | | | | | | | | | | |
| ✓ | | | | *If shade is furnished, what is the square footage of shade per cow in this pen? [0.00]* | | | | | | | | | | | |

## SCREEN 4 - PHYSICAL FACILITIES
## FREESTALLS

| M | D | B | Y | PEN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | | | | Do the animals in this pen have difficulty walking due to manure, etc.? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | | | Does this pen contain areas which would harbor rodents and insects (piles of hay, slag, dirt, tires, trash, etc.)? [T/F] | | | | | | | | | | | |

## SCREEN 5- PHYSICAL FACILITIES
## FREESTALLS

| M | D | B | Y | PEN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | What is the source of water for this pen? [Deep Well (below rock)/ShallowWell/Surface] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the coliform count (in parts/100 ml.) of the water used in this pen (enter 0 if unknown)? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is the water supply to this pen saline? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the nitrate count (in parts/million) of the water used in this pen (enter 0 if unknown)? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Does it take longer than 30 seconds to fill a two-gallon bucket at times of peak demand (milking)? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is there adequate summer ventilation for this pen? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is there adequate winter ventilation for this pen? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is a strong smell of ammonia present in this pen during the summer? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is a strong smell of ammonia present in this pen during the winter? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the predominant breed of the animals in this pen? [Brown Swiss/ Holstein/Jersey/Guernsey/Ayrshire] | | | | | | | | | | | |

For each group of animals indicated previously, we need to obtain information on the physical aspects of the housing, on the animals themselves and on the feed rations used. We will begin with questions on each physical pen or facility and then proceed to the animals comprising each physiological type in each pen and their rations. Depending on whether the pen is a corral, freestall or stanchion facility, and the maturity of the animals in the pen, the questions will differ to some degree.

## SCREEN 1 - PHYSICAL FACILITIES
## STANCHIONS

| M | D | B | Y | PEN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | | | How many stalls are available for use by the animals in this facility? | | | | | | | | | | | |
| ✓ | ✓ | | | What is the average length (in feet) of stalls in this pen? [0.00] | | | | | | | | | | | |
| ✓ | ✓ | | | What is the average width (in feet) of stalls in this pen? [0.00] | | | | | | | | | | | |
| ✓ | ✓ | | | Do the animals in this group have an exercise yard? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | | | *Is the yard surface concrete? [T/F]* | | | | | | | | | | | |
| ✓ | ✓ | | | *If yard surface is not concrete, what is the surface slope (percent) of the yard?* | | | | | | | | | | | |
| ✓ | ✓ | | | *If yard surface is not concrete, are there excessive mud conditions in this pen during any part of the year? [T/F]* | | | | | | | | | | | |
| ✓ | ✓ | | | Does this pen contain areas which would harbor rodents and insects (piles of hay, slag, dirt, tires, trash, etc.)? [T/F] | | | | | | | | | | | |

M = Milk Cow
D = Dry Cow
B = Bred Heifer
Y = Young Stock

## SCREEN 2- PHYSICAL FACILITIES
## STANCHIONS

| M | D | B | Y | PEN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | What is the source of water for this pen? [Deep Well (below rock)/ShallowWell/Surface] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the coliform count (in parts/100 ml.) of the water used in this pen (enter 0 if unknown)? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is the water supply to this pen saline? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the nitrate count (in parts/million) of the water used in this pen (enter 0 if unknown)? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Does it take longer than 30 seconds to fill a two-gallon bucket at times of peak demand (milking)? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is there adequate summer ventilation for this pen? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is there adequate winter ventilation for this pen? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is a strong smell of ammonia present in this pen during the summer? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is a strong smell of ammonia present in this pen during the winter? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the predominant breed of the animals in this pen? [Brown Swiss/ Holstein/Jersey/Guernsey/Ayrshire] | | | | | | | | | | | |

The next set of screens will have questions pertaining to the animals in each pen, their condition and rations. One set of questions should be completed for each physiological group identified previously for each pen.

## SCREEN 1 - NUTRITION

| M | D | B | Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | | | | How frequently are the cows in this group milked? | | | | | | | | | | | |
| ✓ | | | | Are daily milk weights obtained for the milking cows in this group? [T/F] | | | | | | | | | | | |
| ✓ | | | | Enter somatic cell linear score of milk from animals in this group [0.00]. | | | | | | | | | | | |
| ✓ | | | | Enter somatic cell count of milk from animals in this group [i.e. 300]. | | | | | | | | | | | |
| ✓ | | | | Is pre-milk teat dipping used on the animals in this group? [T/F] | | | | | | | | | | | |
| ✓ | | | | Is post-milk teat dipped used on the animals in this group? [T/F] | | | | | | | | | | | |
| ✓ | | | | Do the cows in this group eat longer than 30 minutes after feed is offered? [T/F] | | | | | | | | | | | |
| ✓ | | | | What is the average time per day that animals in this group do not have access to the manger [i.e. 3.5 hours]? | | | | | | | | | | | |

# SCREEN 2 - NUTRITION

| M | D | B | Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | Is the hair coat of 10% (or more) of the animals in this group rough? [T/F] | | | | | | | | | | | |
| ✓ | | | | What is the body condition score at calving of animals in this group? [0.00] | | | | | | | | | | | |
| ✓ | | | | What is the body condition score of animals in this group at 30 days in milk? [0.00] | | | | | | | | | | | |
| ✓ | | | | What is the body condition score at 90 days after calving of animals in this group? [0.00] | | | | | | | | | | | |
| ✓ | | | | What percentage of animals in this group loses a full (1) BC score by 30 days in milking? [0.00] | | | | | | | | | | | |
| ✓ | | | | What percent of the animals in this group have a BC score of greater than 3.5? [0.00] | | | | | | | | | | | |
| ✓ | | | | What percent of the animals in this group have a BC score of less than 2.5? [0.00] | | | | | | | | | | | |

## SCREEN 3 - NUTRITION

| M | D | B | Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | | | | What is the percentage incidence of feet/leg problems in this group? [0.00] | | | | | | | | | | | |
| ✓ | | | | What is the percentage of primary ketosis in this group? [0.00] | | | | | | | | | | | |
| ✓ | | | | What is the percent incidence of milk fever in this group? [0.00] | | | | | | | | | | | |
| ✓ | | | | What is the percent incidence of retained placenta in this group? [0.00] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Are the animals in this group dewormed (if exposed to pasture)? [T/F] *[In southern climates where there is no winter kill of parasites, are the cattle dewormed either four times a year, at time of dry off, or at time of calving ?]* *[In northern climates where there is a winter kill of parasites, are the cattle dewormed twice in the spring ]* | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | From your observation, are the animals afraid of the herdsman when unaccompanied by visitors? [T/F] | | | | | | | | | | | |
| | | ✓ | | What is the average body weight of animals in this group at calving? [0.00] | | | | | | | | | | | |

## SCREEN 4 - NUTRITION
## [Corrals & Freestalls Only]

| M D B Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | For each milking, enter the amount of time the last one-third of the group spends in the holding area and milking parlor (i.e. 0.5 hours). | | | | | | | | | | | |
| ✓ | What percent of animals in the group are dirty (i.e. heavily coated with manure)? | | | | | | | | | | | |

## SCREEN 5 - NUTRITION

| M D B Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | *If daily milk weights are taken, are they used to adjust feed rations, check animal health, or check animals for breeding? [T/F]* | | | | | | | | | | | |
| ✓ | How frequently are animals fed (do not include times food is swept up to cows)? | | | | | | | | | | | |
| ✓ | How many times per day is feed swept up to the cows? | | | | | | | | | | | |
| ✓ | Do the animals in this group receive a total mixed ration? [T/F] | | | | | | | | | | | |
| ✓ | Do the animals in this group receive concentrate? [T/F] | | | | | | | | | | | |
| ✓ | Do the animals in this group receive corn silage? [T/F] | | | | | | | | | | | |
| ✓ | Do the animals in this group receive dry hay? [T/F] | | | | | | | | | | | |
| ✓ | Do the animals in this group receive hay crop silage? [T/F] | | | | | | | | | | | |
| ✓ | Do the animals in this group receive pasture? [T/F] | | | | | | | | | | | |

## SCREEN 6 - NUTRITION

| M D B Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | *If TMR is not fed (and corn silage and hay crop silage is fed), is corn silage fed before hay crop silage? [T/F]* | | | | | | | | | | | |

## SCREEN 7 - NUTRITION

| M D B Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | *If TMR is not fed (and concentrate and hay crop silage is fed), is concentrate fed before hay crop silage? [T/F]* | | | | | | | | | | | |

## SCREEN 8 - NUTRITION

| M D B Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | *If TMR is not fed (and concentrate and dry hay is fed), is dry hay fed before concentrate? [T/F]* | | | | | | | | | | | |

## SCREEN 9 - NUTRITION

| M D B Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | *If the animals receive pasture, is supplemental forage fed when animals are on pasture? [T/F]* | | | | | | | | | | | |
| ✓ | *When on pasture, is the distance to water excessive (> 1/4 mile) for this group? [T/F]* | | | | | | | | | | | |

## SCREEN 10 - NUTRITION

| M | D | B | Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | | | | Does the manure from animals in this group contain whole or partial kernels of corn? [T/F] | | | | | | | | | | | |
| ✓ | | | | Is the manure from animals in this group watery? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is a chemical and dry matter analysis of each forage lot performed on the roughage given the animals in this group? [T/F] | | | | | | | | | | | |
| ✓ | | | | Is there evidence of an empty manger or the animals not being fed ad lib in this group? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is moldy feed present in the manger of this pen? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is secondary fermentation present in the feed of the manger of this pen during the summer? [T/F] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Is secondary fermentation present in the feed of the manger of this pen during the winter? [T/F] | | | | | | | | | | | |
| ✓ | | | | Do you feed poor quality forage to lactating cows in this pen because of inadequate inventory at any time during the year? [T/F] | | | | | | | | | | | |

# SCREEN 11 - NUTRITION

| M | D | B | Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | Do the animals in this group receive trace minerals (either free choice or in the ration)? [T/F] | | | | | | | | | | | |
| ✓ | | | | Do you provide free-choice salt to these animals? [T/F] | | | | | | | | | | | |
| ✓ | | | | *For freestall or corral facilities, is concentrate fed only in the bunk for these animals (i.e. not from computer feeders, etc.)? [T/F]* | | | | | | | | | | | |
| ✓ | | | | *For stanchion facilities, are the milk cows grouped and/or are manger partitions used between cows? [T/F]* | | | | | | | | | | | |
| ✓ | | | | *For stanchion facilities, is feed provided after milking? [T/F]* | | | | | | | | | | | |
| ✓ | | | | *For early lactation milk cows, are the animals in this pen fed the high group ration immediately post-partum? [T/F]* | | | | | | | | | | | |
| | | ✓ | ✓ | *For bred heifers, & young stock, are ionophores given these animals? [T/F]* | | | | | | | | | | | |
| | ✓ | ✓ | | *For dry cows and bred heifers, are the animals moved to a close-up feeding group within three weeks of parturition? [T/F]* | | | | | | | | | | | |
| | ✓ | ✓ | ✓ | Do the animals in this group receive pasture? [T/F] | | | | | | | | | | | |

# SCREEN 12 - NUTRITION
# RATION CONCENTRATES

The next set of screens is designed to obtain information on the composition of the ration currently being fed animals in this pen. Please select up to **NINE** concentrate and forage and **EIGHT** mineral ingredients. Below is a list of the possible ingredients.

If an ingredient is used, enter the amount of that ingredient that is in the ration.

REMEMBER, NO MORE THAN NINE ITEMS CAN BE SELECTED FOR FORAGES AND CONCENTRATES COMBINED. If more are used, then to go the Combine Feed worksheet to combine some of the feeds to stay within the limit of nine concentrates and forages and eight minerals. If a feed you are feeding is not included in the list below, then go to the New Feed worksheet.

| GROUP NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALFALFA | | | | | | | | | | | | |
| meal,17p dehydrated | 1-00-023 | | | | | | | | | | | |
| ALMOND* | | | | | | | | | | | | |
| hulls, 11%crude fiber | 4-00-358 | | | | | | | | | | | |
| hulls, 15%crude fiber | 4-00-359 | | | | | | | | | | | |
| hulls, w shells | 1-27-475 | | | | | | | | | | | |
| APPLES* | | | | | | | | | | | | |
| pomace, w oathulls | 4-28-096 | | | | | | | | | | | |
| pomace, wo oathulls | 4-00-423 | | | | | | | | | | | |
| BAKERY WASTE | | | | | | | | | | | | |
| dehydrated | 4-00-466 | | | | | | | | | | | |
| BARLEY* | | | | | | | | | | | | |
| grain | 4-00-549 | | | | | | | | | | | |
| grain, Pacific | 4-07-939 | | | | | | | | | | | |
| grain screenings | 4-00-542 | | | | | | | | | | | |
| malt sprouts, dehydr. | 5-00-545 | | | | | | | | | | | |
| BEAN, Navy | | | | | | | | | | | | |
| seeds | 5-00-623 | | | | | | | | | | | |
| BEETS, Sugar* | | | | | | | | | | | | |
| aerial part, silage | 3-00-660 | | | | | | | | | | | |
| pulp, dehydrated | 4-00-669 | | | | | | | | | | | |
| pulp, wet | 4-00-671 | | | | | | | | | | | |
| pulp w/molasses deh. | 4-00-672 | | | | | | | | | | | |
| BLOOD | | | | | | | | | | | | |
| meal | 5-00-380 | | | | | | | | | | | |
| BREWERS GRAIN* | | | | | | | | | | | | |
| dehydrated | 5-02-141 | | | | | | | | | | | |
| wet | 5-02-142 | | | | | | | | | | | |
| BUCKWHEAT* | | | | | | | | | | | | |
| grain | 4-00-994 | | | | | | | | | | | |
| middlings | 5-00-991 | | | | | | | | | | | |
| CARROT | | | | | | | | | | | | |
| roots, fresh | 4-01-145 | | | | | | | | | | | |

| GROUP NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CASEIN | | | | | | | | | | | | |
| dehydrated | 5-01-162 | | | | | | | | | | | |
| CITRUS* | | | | | | | | | | | | |
| pulp, silage | 3-01-234 | | | | | | | | | | | |
| dried pulp | 4-01-237 | | | | | | | | | | | |
| COCONUT | | | | | | | | | | | | |
| meat, mech-ext | 5-01-572 | | | | | | | | | | | |
| CORN, Dent Yellow* | | | | | | | | | | | | |
| cobs, ground | 1-28-234 | | | | | | | | | | | |
| dstlrs grain, dehy. | 5-28-235 | | | | | | | | | | | |
| dstlrs grain, wet | 5-28-234 | | | | | | | | | | | |
| dstlrs w/solubles | 5-28-236 | | | | | | | | | | | |
| dsstlrs solubles | 5-28-237 | | | | | | | | | | | |
| ears, dry | 4-28-238 | | | | | | | | | | | |
| ear, high moisture | 4-20-771 | | | | | | | | | | | |
| germ, meal | 5-28-238 | | | | | | | | | | | |
| gluten, feed (w/bran) | 5-28-239 | | | | | | | | | | | |
| gluten, meal | 5-28-241 | | | | | | | | | | | |
| gluten, meal 60p | 5-28-242 | | | | | | | | | | | |
| grain, cracked | 4-20-698 | | | | | | | | | | | |
| grain, ground | 4-02-931 | | | | | | | | | | | |
| grain, flaked | 4-28-244 | | | | | | | | | | | |
| grain,hi. moisture 45 | 4-20-770 | | | | | | | | | | | |
| grits byprod(hominy) | 4-03-011 | | | | | | | | | | | |
| COTTON* | | | | | | | | | | | | |
| hulls | 1-01-599 | | | | | | | | | | | |
| seeds, w lint | 5-01-614 | | | | | | | | | | | |
| seeds, wo lint | 5-01-613 | | | | | | | | | | | |
| seeds, meal 41 p | 5-01-617 | | | | | | | | | | | |
| seeds, prp 44 p | 5-07-873 | | | | | | | | | | | |
| FAT | | | | | | | | | | | | |
| CA salts | 4-00-001 | | | | | | | | | | | |
| FATS & OILS* | | | | | | | | | | | | |
| fat,animalhydrolized | 4-00-376 | | | | | | | | | | | |
| fat, swine lard | 4-04-790 | | | | | | | | | | | |
| oil, soybean | 4-07-983 | | | | | | | | | | | |
| FISH* | | | | | | | | | | | | |
| menhaden | 5-02-009 | | | | | | | | | | | |
| white | 5-02-025 | | | | | | | | | | | |
| FLAX* | | | | | | | | | | | | |
| seed screenings | 4-02-056 | | | | | | | | | | | |
| seeds, meal mech-ext | 5-02-045 | | | | | | | | | | | |
| meal, solv-ext | 5-02-048 | | | | | | | | | | | |
| GRAPE | | | | | | | | | | | | |
| marc, dehydrated | 1-02-208 | | | | | | | | | | | |

| GROUP NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HEMICELLULOSE | | | | | | | | | | | | |
| molasses, wood | 4-08-030 | | | | | | | | | | | |
| MEAT* | | | | | | | | | | | | |
| meal, rendered | 5-00-385 | | | | | | | | | | | |
| w blood | 5-00-386 | | | | | | | | | | | |
| w blood, bone | 5-00-387 | | | | | | | | | | | |
| w bone | 5-00-388 | | | | | | | | | | | |
| MILK* | | | | | | | | | | | | |
| dehydrated (cattle) | 5-01-167 | | | | | | | | | | | |
| fresh (cattle) | 5-01-168 | | | | | | | | | | | |
| skim dehy. (cattle) | 5-01-175 | | | | | | | | | | | |
| skim fresh (cattle) | 5-01-170 | | | | | | | | | | | |
| MILLET* | | | | | | | | | | | | |
| foxtail, fresh | 2-03-101 | | | | | | | | | | | |
| foxtail, grain | 4-03-102 | | | | | | | | | | | |
| Proso,grain | 4-03-120 | | | | | | | | | | | |
| MOLASSES & SYRUP* | | | | | | | | | | | | |
| molasses, black strap | 4-04-696 | | | | | | | | | | | |
| molasses, cane dehy | 4-04-695 | | | | | | | | | | | |
| molasses, sugar beet | 4-00-668 | | | | | | | | | | | |
| syrup, citrus | 4-01-241 | | | | | | | | | | | |
| OATS* | | | | | | | | | | | | |
| cereal by prod | 4-03-303 | | | | | | | | | | | |
| grain | 4-03-309 | | | | | | | | | | | |
| grain, Pacific | 4-07-999 | | | | | | | | | | | |
| groats | 4-03-331 | | | | | | | | | | | |
| hulls | 1-03-281 | | | | | | | | | | | |
| ORANGE* | | | | | | | | | | | | |
| pulp, wo fines | 4-01-254 | | | | | | | | | | | |
| fresh, whole | 4-01-253 | | | | | | | | | | | |
| PEA | | | | | | | | | | | | |
| seeds | 5-03-600 | | | | | | | | | | | |
| PEANUT* | | | | | | | | | | | | |
| hulls | 1-08-028 | | | | | | | | | | | |
| kernels, mech-ext | 5-03-649 | | | | | | | | | | | |
| kernels, solv-ext | 5-03-650 | | | | | | | | | | | |
| POTATO* | | | | | | | | | | | | |
| process residue, dehy | 4-03-775 | | | | | | | | | | | |
| tubers, dehydrated | 4-07-850 | | | | | | | | | | | |
| tubers, fresh | 4-03-787 | | | | | | | | | | | |
| tubers, silage | 4-03-768 | | | | | | | | | | | |

| GROUP NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RAPE (Canola)* | | | | | | | | | | | | |
| seeds, mech-ext | 5-03-870 | | | | | | | | | | | |
| seeds, solv-ext | 5-03-871 | | | | | | | | | | | |
| rape (Summer)(Can.) | | | | | | | | | | | | |
| seeds, mech-ext | 5-08-136 | | | | | | | | | | | |
| seeds, solv-ext | 5-08-135 | | | | | | | | | | | |
| RICE* | | | | | | | | | | | | |
| bran, w germ | 4-03-928 | | | | | | | | | | | |
| grain, rough | 4-03-938 | | | | | | | | | | | |
| grain, polishd | 4-03-932 | | | | | | | | | | | |
| groats, polishd | 4-03-942 | | | | | | | | | | | |
| hulls | 1-08-075 | | | | | | | | | | | |
| RYE* | | | | | | | | | | | | |
| dstlrs grain, dehy | 5-04-023 | | | | | | | | | | | |
| grain | 4-04-047 | | | | | | | | | | | |
| SAFFLOWER* | | | | | | | | | | | | |
| seeds | 4-07-958 | | | | | | | | | | | |
| seeds, meal mech-ext | 5-04-109 | | | | | | | | | | | |
| seeds, meal solv-ext | 5-04-110 | | | | | | | | | | | |
| seeds, wo hulls, meal | 5-07-959 | | | | | | | | | | | |
| SESAME | | | | | | | | | | | | |
| seeds, meal mech-ext | 5-04-220 | | | | | | | | | | | |
| SORGHUM (Milo)* | | | | | | | | | | | | |
| grain > 10% p | 4-20-894 | | | | | | | | | | | |
| hi. moisture or flaked | 4-20-895 | | | | | | | | | | | |
| dstlrs grain, dehy | 5-04-374 | | | | | | | | | | | |
| grain < 8% p | 4-20-892 | | | | | | | | | | | |
| grain 8 - 10 % | 4-20-893 | | | | | | | | | | | |
| SOYBEAN* | | | | | | | | | | | | |
| hulls | 1-04-560 | | | | | | | | | | | |
| seeds, whole raw | 5-04-610 | | | | | | | | | | | |
| seeds, whole roast | 5-04-597 | | | | | | | | | | | |
| seeds, meal mech-ex | 5-04-600 | | | | | | | | | | | |
| seeds, meal 44p | 5-20-637 | | | | | | | | | | | |
| seeds, meal 49p | 5-04-612 | | | | | | | | | | | |
| SUGARCANE | | | | | | | | | | | | |
| bagasse, dehydrated | 1-04-686 | | | | | | | | | | | |
| SUNFLOWER* | | | | | | | | | | | | |
| seeds, meal solv-ex | 5-09-738 | | | | | | | | | | | |
| seeds,wohulls mechex | 5-09-340 | | | | | | | | | | | |
| seeds,wo hulls solv ex | 5-04-739 | | | | | | | | | | | |
| TOMATO | | | | | | | | | | | | |
| pomace, dehydrated | 5-05-041 | | | | | | | | | | | |
| TRITICALE | | | | | | | | | | | | |
| grain | 4-20-362 | | | | | | | | | | | |

| GROUP NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TURNIP | | | | | | | | | | | | |
| roots, fresh | 4-05-067 | | | | | | | | | | | |
| UREA | | | | | | | | | | | | |
| 45 N, 281 p | 5-05-070 | | | | | | | | | | | |
| VETCH | | | | | | | | | | | | |
| hay | 1-05-106 | | | | | | | | | | | |
| WHEAT* | | | | | | | | | | | | |
| bran | 4-05-190 | | | | | | | | | | | |
| flr byprod <7%shorts | 4-05-201 | | | | | | | | | | | |
| flr byprod<9.5%mid. | 4-05-205 | | | | | | | | | | | |
| germ, ground | 5-05-218 | | | | | | | | | | | |
| grain, ground | 4-05-211 | | | | | | | | | | | |
| grain screenings | 4-05-216 | | | | | | | | | | | |
| WHEY* | | | | | | | | | | | | |
| fresh (cattle) | 4-08-134 | | | | | | | | | | | |
| dehydrated | 4-01-182 | | | | | | | | | | | |
| low-lactose, dehy | 4-01-186 | | | | | | | | | | | |
| YEAST | | | | | | | | | | | | |
| brewers, dehydrated | 7-05-527 | | | | | | | | | | | |

# SCREEN 12 - NUTRITION
## RATION FORAGES

| GROUP NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALFALFA* | | | | | | | | | | | | |
| hay, preblm | 1-00-058 | | | | | | | | | | | |
| hay, erlyblm | 1-00-059 | | | | | | | | | | | |
| hay, midblm | 1-00-063 | | | | | | | | | | | |
| hay, mature | 1-00-071 | | | | | | | | | | | |
| hay, weatherda | 1-00-072 | | | | | | | | | | | |
| pasture, erly veg | 2-00-180 | | | | | | | | | | | |
| pasture, late veg | 2-00-181 | | | | | | | | | | | |
| silage, erlyblm | 3-00-216 | | | | | | | | | | | |
| silage, midblm | 3-00-217 | | | | | | | | | | | |
| BAHIAGRASS* | | | | | | | | | | | | |
| fresh | 2-00-464 | | | | | | | | | | | |
| hay, lateveg | 1-20-787 | | | | | | | | | | | |
| BARLEY | | | | | | | | | | | | |
| hay | 1-00-459 | | | | | | | | | | | |
| BERMUDAGRASS* | | | | | | | | | | | | |
| hay, erlyveg | 1-00-713 | | | | | | | | | | | |
| hay, lateveg | 1-20-900 | | | | | | | | | | | |
| hay, 15-28 days | 1-09-208 | | | | | | | | | | | |
| hay, 29-42 days | 1-09-209 | | | | | | | | | | | |
| hay, 43-56 days | 1-09-210 | | | | | | | | | | | |
| BLUEGRASS* | | | | | | | | | | | | |
| Can. fresh, erlyveg | 2-00-763 | | | | | | | | | | | |
| Can. hay, lateveg | 1-20-889 | | | | | | | | | | | |
| Kt. fresh, erlyveg | 2-00-777 | | | | | | | | | | | |
| Kt. fresh, erlyblm | 2-00-781 | | | | | | | | | | | |
| Kt. fresh, milk stage | 2-00-782 | | | | | | | | | | | |
| Kt. fresh, mature | 2-00-784 | | | | | | | | | | | |
| BROME* | | | | | | | | | | | | |
| fresh, erlyveg | 2-00-892 | | | | | | | | | | | |
| fresh, mature | 2-00-898 | | | | | | | | | | | |
| hay, lateveg | 1-00-887 | | | | | | | | | | | |
| hay, lateblm | 1-00-888 | | | | | | | | | | | |
| CLOVER, Aliske* | | | | | | | | | | | | |
| fresh, erlyveg | 2-01-314 | | | | | | | | | | | |
| hay | 1-01-313 | | | | | | | | | | | |
| CLOVER, Crimson* | | | | | | | | | | | | |
| fresh, erlyveg | 2-20-890 | | | | | | | | | | | |
| hay | 1-01-378 | | | | | | | | | | | |
| CLOVER, Ladino* | | | | | | | | | | | | |
| fresh, erlyveg | 2-01-380 | | | | | | | | | | | |
| hay | 1-01-378 | | | | | | | | | | | |

| GROUP NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLOVER, Red* | | | | | | | | | | | | |
| fresh, erlyblm | 2-01-428 | | | | | | | | | | | |
| fresh, fullblm | 2-01-429 | | | | | | | | | | | |
| hay | 1-01-415 | | | | | | | | | | | |
| CLOVER, Sweet* | | | | | | | | | | | | |
| hay | 1-04-754 | | | | | | | | | | | |
| COMBINED FEEDS* | | | | | | | | | | | | |
| | 0-00-001 | | | | | | | | | | | |
| | 0-00-002 | | | | | | | | | | | |
| | 0-00-003 | | | | | | | | | | | |
| | 0-00-004 | | | | | | | | | | | |
| | 0-00-005 | | | | | | | | | | | |
| | 0-00-006 | | | | | | | | | | | |
| | 0-00-007 | | | | | | | | | | | |
| | 0-00-008 | | | | | | | | | | | |
| | 0-00-009 | | | | | | | | | | | |
| | 0-00-010 | | | | | | | | | | | |
| | 0-00-011 | | | | | | | | | | | |
| | 0-00-012 | | | | | | | | | | | |
| | 0-00-013 | | | | | | | | | | | |
| | 0-00-014 | | | | | | | | | | | |
| | 0-00-015 | | | | | | | | | | | |
| CORN, Dent Yellow* | | | | | | | | | | | | |
| aerial part | 1-28-233 | | | | | | | | | | | |
| silage, aerial | 3-28-251 | | | | | | | | | | | |
| silage, 50% GR | 3-28-001 | | | | | | | | | | | |
| silage, 50GR+NPN | 3-28-002 | | | | | | | | | | | |
| sil.,50GR+NPN+CA | 3-28-003 | | | | | | | | | | | |
| silage, 40% GR | 3-28-004 | | | | | | | | | | | |
| silage, 40GR+NPN | 3-28-005 | | | | | | | | | | | |
| sil.,40GR+NPN+CA | 3-28-006 | | | | | | | | | | | |
| silage, 30% GR | 3-28-007 | | | | | | | | | | | |
| silage, 30GR+NPN | 3-28-008 | | | | | | | | | | | |
| sil.,30GR+NPN+CA | 3-28-009 | | | | | | | | | | | |
| silage, few eared | 3-28-245 | | | | | | | | | | | |
| CORN, Sweet | | | | | | | | | | | | |
| process residue | 3-07-955 | | | | | | | | | | | |
| COWPEA, Common | | | | | | | | | | | | |
| hay | 1-01-645 | | | | | | | | | | | |

| GROUP NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FESCUE* | | | | | | | | | | | | |
| hay, erlyveg | 1-06-132 | | | | | | | | | | | |
| hay, lateveg | 1-13-582 | | | | | | | | | | | |
| hay, erlyblm | 1-01-871 | | | | | | | | | | | |
| Ky 31, fresh veg | 2-01-902 | | | | | | | | | | | |
| Ky 31, hay, erlyblm | 1-09-186 | | | | | | | | | | | |
| Ky 31, hay, midblm | 1-09-787 | | | | | | | | | | | |
| Ky 31, hay, fullblm | 1-09-188 | | | | | | | | | | | |
| Ky 31, hay, mature | 1-09-189 | | | | | | | | | | | |
| GRASS* | | | | | | | | | | | | |
| hay, late veg | 1-09-001 | | | | | | | | | | | |
| hay, midblm | 1-09-002 | | | | | | | | | | | |
| hay, mature | 1-09-003 | | | | | | | | | | | |
| pasture, erlyveg | 1-09-004 | | | | | | | | | | | |
| pasture, late veg | 1-09-005 | | | | | | | | | | | |
| pasture, mature | 1-09-006 | | | | | | | | | | | |
| MILLET, Foxtail* | | | | | | | | | | | | |
| fresh | 2-03-101 | | | | | | | | | | | |
| hay | 1-03-099 | | | | | | | | | | | |
| MILLET, Pearl* | | | | | | | | | | | | |
| fresh | 2-03-115 | | | | | | | | | | | |
| silage | 3-20-903 | | | | | | | | | | | |
| MIXED HAY* | | | | | | | | | | | | |
| erlyblm | 1-09-007 | | | | | | | | | | | |
| midlbm | 1-09-008 | | | | | | | | | | | |
| mature | 1-09-009 | | | | | | | | | | | |
| MIXED PASTURE* | | | | | | | | | | | | |
| erly veg | 2-00-001 | | | | | | | | | | | |
| late veg | 2-00-002 | | | | | | | | | | | |
| MIXED SILAGE* | | | | | | | | | | | | |
| erlyblm | 3-00-001 | | | | | | | | | | | |
| midblm | 3-00-002 | | | | | | | | | | | |
| NAPIERGRASS* | | | | | | | | | | | | |
| fresh, lateveg | 2-03-158 | | | | | | | | | | | |
| fresh, lateblm | 2-03-162 | | | | | | | | | | | |

| GROUP NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NEW FEEDS* | | | | | | | | | | | | |
| | 0-00-101 | | | | | | | | | | | |
| | 0-00-102 | | | | | | | | | | | |
| | 0-00-103 | | | | | | | | | | | |
| | 0-00-104 | | | | | | | | | | | |
| | 0-00-105 | | | | | | | | | | | |
| | 0-00-106 | | | | | | | | | | | |
| | 0-00-107 | | | | | | | | | | | |
| | 0-00-108 | | | | | | | | | | | |
| | 0-00-109 | | | | | | | | | | | |
| | 0-00-110 | | | | | | | | | | | |
| | 0-00-111 | | | | | | | | | | | |
| | 0-00-112 | | | | | | | | | | | |
| | 0-00-113 | | | | | | | | | | | |
| | 0-00-114 | | | | | | | | | | | |
| | 0-00-115 | | | | | | | | | | | |
| OATS* | | | | | | | | | | | | |
| hay, boot stage | 1-03-001 | | | | | | | | | | | |
| hay, dough stage | 1-03-002 | | | | | | | | | | | |
| hay, head emerging | 1-03-003 | | | | | | | | | | | |
| silage, dough stage | 3-03-280 | | | | | | | | | | | |
| straw | 1-03-283 | | | | | | | | | | | |
| ORCHARDGRASS* | | | | | | | | | | | | |
| fresh, erlyveg | 2-03-439 | | | | | | | | | | | |
| hay, erlyblm | 1-03-425 | | | | | | | | | | | |
| hay, lateblm | 1-03-428 | | | | | | | | | | | |
| PANGOLAGRASS* | | | | | | | | | | | | |
| hay, 15-28 days | 1-10-638 | | | | | | | | | | | |
| hay, 29-42 days | 1-26-214 | | | | | | | | | | | |
| hay, 43-56 days | 1-29-573 | | | | | | | | | | | |
| PEA | | | | | | | | | | | | |
| vines, wo seeds | 3-03-596 | | | | | | | | | | | |
| PEANUT | | | | | | | | | | | | |
| hay | 1-03-619 | | | | | | | | | | | |
| RAPE (Canola) | | | | | | | | | | | | |
| fresh, erlyveg | 2-03-865 | | | | | | | | | | | |
| REDTOP* | | | | | | | | | | | | |
| fresh | 2-03-897 | | | | | | | | | | | |
| hay, midblm | 1-03-886 | | | | | | | | | | | |
| RYE* | | | | | | | | | | | | |
| pasture | 2-04-018 | | | | | | | | | | | |
| silage | 3-04-020 | | | | | | | | | | | |
| straw | 1-04-007 | | | | | | | | | | | |

| GROUP NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RYEGRASS, Italian* | | | | | | | | | | | | |
| hay,erlyveg | 1-04-064 | | | | | | | | | | | |
| hay, lateveg | 1-04-065 | | | | | | | | | | | |
| hay, erlyblm | 1-04-066 | | | | | | | | | | | |
| RYEGRASS, Perennial | | | | | | | | | | | | |
| hay | 1-04-077 | | | | | | | | | | | |
| SORGHUM (Milo)* | | | | | | | | | | | | |
| aerial part, w heads | 1-07-960 | | | | | | | | | | | |
| aerial part, wo heads | 1-04-302 | | | | | | | | | | | |
| silage | 3-04-323 | | | | | | | | | | | |
| Johnsongr. hay | 1-04-407 | | | | | | | | | | | |
| Sorgo silage | 3-04-468 | | | | | | | | | | | |
| SORGHUM,Sudangr.* | | | | | | | | | | | | |
| fresh, erlyveg | 2-04-484 | | | | | | | | | | | |
| fresh, midblm | 2-04-485 | | | | | | | | | | | |
| hay, fullblm | 1-04-480 | | | | | | | | | | | |
| silage | 3-04-499 | | | | | | | | | | | |
| SOYBEAN* | | | | | | | | | | | | |
| hay, midblm | 1-04-538 | | | | | | | | | | | |
| hay, dough stage | 1-04-542 | | | | | | | | | | | |
| SUNFLOWER* | | | | | | | | | | | | |
| silage, low-oil | 5-04-001 | | | | | | | | | | | |
| silage, high-oil | 5-04-002 | | | | | | | | | | | |
| TIMOTHY* | | | | | | | | | | | | |
| hay, lateveg | 1-04-991 | | | | | | | | | | | |
| hay, erlyblm | 1-04-882 | | | | | | | | | | | |
| hay, midblm | 1-04-883 | | | | | | | | | | | |
| hay, fullblm | 1-04-884 | | | | | | | | | | | |
| hay, lateblm | 1-04-885 | | | | | | | | | | | |
| hay, milk stage | 1-04-886 | | | | | | | | | | | |
| TREFOIL* | | | | | | | | | | | | |
| birdsfoot, fresh | 2-20-786 | | | | | | | | | | | |
| birdsfoot, hay | 1-05-044 | | | | | | | | | | | |
| TRITICALE | | | | | | | | | | | | |
| silage, head emerging | 4-20-363 | | | | | | | | | | | |
| WHEAT* | | | | | | | | | | | | |
| fresh, erly veg | 2-05-176 | | | | | | | | | | | |
| hay | 1-05-172 | | | | | | | | | | | |
| silage, erlyveg | 3-05-184 | | | | | | | | | | | |
| straw | 1-05-175 | | | | | | | | | | | |
| YEAST | | | | | | | | | | | | |

# SCREEN 13 - NUTRITION
# RATION MINERALS

| GROUP NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MINERAL | | | | | | | | | | | | |
| Bone Meal Steamed | 6-00-400 | | | | | | | | | | | |
| CA Carbonate | 6-01-069 | | | | | | | | | | | |
| CA Phos Monobasic | 6-01-082 | | | | | | | | | | | |
| Calcium Sulfate | 6-01-089 | | | | | | | | | | | |
| Deflor Phos | 6-01-780 | | | | | | | | | | | |
| Dical Phos | 6-01-080 | | | | | | | | | | | |
| Dynamate | 6-01-870 | | | | | | | | | | | |
| Limestone (Ground) | 6-02-631 | | | | | | | | | | | |
| Limeston (Mg,Dolmi.) | 6-02-632 | | | | | | | | | | | |
| Magnes Oxide | 6-02-630 | | | | | | | | | | | |
| Monona Phos | 6-04-228 | | | | | | | | | | | |
| Potas Chlor | 6-05-001 | | | | | | | | | | | |
| Potas Sulfate | 6-05-002 | | | | | | | | | | | |
| Salt | 6-05-003 | | | | | | | | | | | |
| Sodium Bicarb | 6-05-005 | | | | | | | | | | | |
| Sodium Sulfate | 6-05-004 | | | | | | | | | | | |
| Trace Mineral Salt | 6-05-006 | | | | | | | | | | | |

## SCREEN 14 - NUTRITION
## RATION [CONCENTRATES & FORAGES] SUMMARY

For the ration ingredients indicated on the previous sheets, answer the following question and denote the amount [lbs/animal/day] of each making-up the total ration. In the far right column indicate [T/F] whether you have a chemical analysis on any of the feed ingredients listed. Chemical analyses for combined feeds and new feeds are entered on the Excel worksheet applicable to these ingredients and should not be indicated here.

NOTE: Mineral amounts will be considered separately.

Please enter whether the feed ingredients listed are fed on a dry matter basis or as feed basis. ____________________

| Feed Ingredient | Int. Ref. No. | lbs/animal/day | Chemical Analysis [T/F] |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |

## SCREEN 15 - NUTRITION
## RATION [MINERALS] SUMMARY

| Mineral Ingredient | Int. Ref. No. | lbs/animal/day |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |

## SCREEN 16 - NUTRITION
## CHEMICAL ANALYSIS FOR CONCENTRATES AND FORAGES

| | Feed 1 | Feed 2 | Feed 3 | Feed 4 | Feed 5 | Feed 6 | Feed 7 | Feed 8 | Feed 9 |
|---|---|---|---|---|---|---|---|---|---|
| Name | | | | | | | | | |
| Int. Ref. No. | | | | | | | | | |
| Dry Matter %AF | | | | | | | | | |
| Fat %DM | | | | | | | | | |
| Ash %DM | | | | | | | | | |
| NDF %DM | | | | | | | | | |
| Crude Protein %DM | | | | | | | | | |
| Solubility %CP | | | | | | | | | |
| TDN %DM | | | | | | | | | |
| Net Energy (L) MCAL/LB | | | | | | | | | |
| Calcium %DM | | | | | | | | | |
| Phosphorous %DM | | | | | | | | | |
| Magnesium %DM | | | | | | | | | |
| Potassium %DM | | | | | | | | | |
| Sulfur %DM | | | | | | | | | |
| Sodium %DM | | | | | | | | | |

In order to accurately assess the adequacy of your current ration for this group
we need additional information on the animals
environmental factors
and your management objectives.

## SCREEN 17 - NUTRITION

| M | D | B | Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | What is the average age of animals in this group (in months)? [00.00] | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the average body weight of animals in this group (lbs.)? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the average number of days pregnant for animals in this group? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the average number of days since calving for animals in this group? | | | | | | | | | | | |
| ✓ | | | | What is the average milk production per cow per day for animals in this group (lbs.)? | | | | | | | | | | | |
| ✓ | | | | What is the percentage butterfat of milk from this group of animals? [0.00] | | | | | | | | | | | |
| ✓ | | | | What is the percentage milk protein of milk from this group of animals? [0.00] | | | | | | | | | | | |

## SCREEN 18 - NUTRITION

| M | D | B | Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | What is the average rate of daily gain or lose for animals in this group (lbs./day)? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the average expected birth weight for calves from these animals (lbs.)? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | *If on pasture, what is the grazing unit size for animals in this group (acres of pasture/cow)?* | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the average wind speed (MPH) during the current month? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the average temperature (°F) during the past month (where the cows are housed; i.e., in the barn)? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the average temperature (°F) during the current month? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the average relative humidity (%) for the current month? | | | | | | | | | | | |

## SCREEN 19 - NUTRITION

| M | D | B | Y | GROUP NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | Are nights generally cooler than the daytime period for this group of animals at this time of the year (1=no; 2=night cooling)? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the average hair depth for animals in this group (ave. in increments of 0.1 inches)? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | What is the average amount of mud covering animals in this pen [No mud/Some mud on lower body/ Mud on lower body and sides/ Heavily covered with mud]? | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Do the cattle pant in summer [None/ Rapid shallow/Open mouth]. | | | | | | | | | | | |
| ✓ | ✓ | ✓ | ✓ | Are animals in this group subject to storm exposure? [T/F] | | | | | | | | | | | |

| Next we need to obtain information on reproduction statistics and maternity area factors as they pertain to your entire herd. |
|---|

## SCREEN 1 - MATERNITY AREA AND REPRODUCTION

| | |
|---|---|
| What is the average number of services per conception? | |
| What is the average number of days between calving and first service? | |
| What is the average number of days between calving and conception? | |
| What is the voluntary waiting period breeding policy (days)? | |
| What is the average age (in months) of heifers at first calving? | |
| Are 10% or more of the heifers reaching 400 lbs. bodyweight greater than 180 days of age? [T/F] | |
| How many square feet are available per cow in the maternity area during peak usage? | |
| Type of maternity area used [Pen,/Pasture,/Bedded pack/Dry lot]. | |

## SCREEN 2 - MATERNITY AREA AND REPRODUCTION

| | |
|---|---|
| *If the type of maternity area used is "pen," how many pens are available for use at any given time?* | |
| Is the location of the maternity area separate from the remainder of the herd? [T/F] | |
| Is the maternity area dry? [T/F] | |
| Is there sufficient lighting in the maternity area to read a newspaper? [T/F] | |
| Is the ventilation in the maternity area adequate so that the air does not feel damp or smell stale? [T/F] | |
| Is the maternity area free of mud? [T/F] | |
| Is the maternity area cleaned and disinfected after every calving, if a pen, or cleaned regularly and dried if a bedded pack? [T/F] | |
| What is the average length of dry period for this herd (days)? | |

## SCREEN 3 - MATERNITY AREA AND REPRODUCTION

| | |
|---|---|
| For this herd, what is the incidence of abortions? [percent] | |
| For this herd, what percent of the calves are born dead? | |
| What is the percent calf mortality (after 24 hours of age)? | |
| Do greater than 20% of the births require assistance? | |
| Do the calves receive a minimum of two quarts of colostrum within the first six hours after birth? [T/F] | |
| Do you feed low quality colostrum more than 5% of the time? [T/F] | |
| Have the young stock had problems with calf scours? [T/F] | |
| What percent of the calves are dirty (i.e. heavily coated with manure)? | |

## SCREEN 1 - GENERAL MANAGEMENT

The following questions concern general farm management practices. Questions on the first four pages will normally require a direct response from the operator or owner. Questions on the last two pages should be answered from observation based upon the farm inspection or from general discussions with the operator while the review session is taking place. A series of carefully planned questions may be required to form appropriate subjective judgements concerning a given question

.

| | |
|---|---|
| Is a reliable disinfectant solution used in milking equipment washup and is it rinsed thoroughly after cleansing? [T/F] | |
| Are hot water cleansing systems used to sanitize milking systems? [T/F] | |
| Does the operator make extensive use of the DHIA data? [T/F] | |
| Are DHIA Summary Sheets, Individual Summary Sheets, Current Tester's Record, etc.) largely consistent in the number of cows shown? [T/F] | |
| Is the current barn sheet actually used as the central data sheet for "cow status information ?" [T/F] | |
| Is a central or main medical record book (or the equivalent) maintained on the animals? [T/F] | |
| Are ALL medical treatments recorded (inc. milk fever and ketosis) and do drug usage records match pharmaceutical purchase records? [T/F] | |
| Are all medical records updated on a scheduled basis and not a "when there's time" basis? [T/F] | |

## SCREEN 2 - GENERAL MANAGEMENT

| | |
|---|---|
| Are central breeding records kept for year-to-year comparisons? [T/F] | |
| Is a record kept of the bull(s) used to breed each cow and is the performance of the bull and cow recorded? [T/F] | |
| Do you call a veterinarian for the following? | |
| *Emergencies? [T/F]* | |
| *Regular reproductive herd checks? [T/F]* | |
| *Regular consultations concerning total herd health? [T/F]* | |
| Is a nutrition consultant systematically used to achieve specific feed management goals? [T/F] | |
| Are the lactating animals divided into two to four strings (production ranges) with each string having animals within 25 pounds production of each other? [T/F] | |
| Is the means of weighing feed available, accurate, convenient to use, and consistently used? [T/F] | |
| Are trade and professional journals (i.e., Hoard's Dairyman or Dairy Herd Management) taken and relevant articles read? [T/F] | |

## SCREEN 3 - GENERAL MANAGEMENT

| | |
|---|---|
| How many farm operators are there? | |
| How many people (inc. operators) are employed at this dairy? | |
| Is there a consistent pattern of high turnover of employees (i.e., job durations < than 12 months)? [T/F] | |
| Does the manager participate in and encourage continuing education for staff (including paying for this type of activity)? [T/F] | |
| Are there well-organized herd and financial records, kept neatly, and prepared on a scheduled basis? [T/F] | |
| Are expense and financial records "reasonably" up to date, and is there a system for updating them? [T/F] | |
| Answers to the following are important for providing remedial advice. | |
| *What is the net farm income for this dairy (enter 0 if unknown)?* | |
| *What is the debt equity ratio of this farm (enter 0 if unknown)?* | |
| *What is the farm's cash flow coverage ratio (enter 0 if unknown)?* | |

## SCREEN 4 - GENERAL MANAGEMENT

| | |
|---|---|
| What is this dairy's cull rate [percent]? | |
| Has the size of the milking herd expanded over the last five years by more than 20 cows? [T/F] | |
| Do the farm operators for this dairy have expansion plans (to increase the number of cows) for the next three years? [T/F] | |
| Does the dairyman have a milk price forecast and an explanation for how it was derived? [T/F] | |
| Does the manager know what percentage of operating expenses goes for feed and the interest on loans for feed purchases that are part of this cost? [T/F] | |
| What is the average dairy feed and crop expense ($) per 100 pounds of milk shipped (please use an accrual accounting value if possible)? | |
| Does the manager have the cash flow flexibility to purchase feed? [T/F] | |

## SCREEN 5 - GENERAL MANAGEMENT
## [Answer Questions On Next Two Screens From Observation]

| | |
|---|---|
| Does the herdsman have a basic knowledge of cow behavior (i.e., an understanding of dominant animals or the pecking order in the herd)? [T/F] | |
| Does the manager thoroughly understand all items on the barn sheet? [T/F] | |
| Are current record sheets available (in work area) for posting data? [T/F] | |
| Do milkers adhere to strict cleanliness procedures, including cleaning empty stalls and using single-use towels for drying udders? [T/F] | |
| Are cows primed before milking with mastitis cows milked separately & marked for treatment? [T/F] | |
| Can water run down onto the udder while the cows are being milked? [T/F] | |
| Is concentrate fed largely or solely during milking time? [T/F] | |
| Does the milk room wash and rinse vat have two separate compartments? [T/F] | |
| Is milking equipment stored on clean, spacious racks above floor level? [T/F] | |

## SCREEN 6 - GENERAL MANAGEMENT

| | |
|---|---|
| Are milking surfaces (floors, walls, ceiling) non-porous, scrubbable and clean throughout? [T/F] | |
| Is there adequate ventilation and light in the parlor/barn (sufficient to id cow tags, inspect udders and to dry floors between milkings)? [T/F] | |
| Are new ideas from outside consultants or subordinates considered and tried, as opposed to being; judged inferior to current procedures? [T/F] | |
| Are staff decision-making procedures consistent (i.e., are employees delegated responsibility and allowed full authority to execute it)? [T/F] | |
| Is there a positive relationship with employees (not adversarial) and is there an effective system for airing grievances and complaints? [T/F] | |
| Does the manager have a good overview of the dairy's financial picture and is s/he able to identify the factors that contribute to this picture? [T/F] | |
| Does the dairy have plans for the future that give adequate consideration to the financial picture? [T/F] | |

## COMBINE FEEDS EXCEL WORKSHEET

Please enter how many feeds you are combining (2 or 3): __________
[Up to three feeds can be combined into one]

Please enter whether feeds being combined are fed on:
0 = dry matter basis, 1 = as feed basis __________

Combination Int. Ref. No.: ______________
(0-00-001, 0-00-002, ... 0-00-015)

Combination Name: __________________________

Feeds to be combined:

| | Feed 1 | Feed 2 | Feed 3 |
|---|---|---|---|
| Int. Ref. No. | | | |
| Name | | | |
| Amount | | | |

Do you have a chemical analysis for any of these feeds? _________
0 = no, 1 = yes

## CHEMICAL ANALYSIS FOR FEEDS BEING COMBINED

How many analysis are you entering for this combination? ______

| | Feed 1 | Feed 2 | Feed 3 |
|---|---|---|---|
| Name | | | |
| Int. Ref. No. | | | |
| Dry Matter %AF | | | |
| Fat %DM | | | |
| Ash %DM | | | |
| NDF %DM | | | |
| Crude Protein %DM | | | |
| Solubility %CP | | | |
| TDN %DM | | | |
| Net Energy (L) MCAL/LB | | | |
| Calcium %DM | | | |
| Phosphorous %DM | | | |
| Magnesium %DM | | | |
| Potassium %DM | | | |
| Sulfur %DM | | | |
| Sodium %DM | | | |

# NEW FEEDS EXCEL WORKSHEET

How many New Feeds are you entering? ________

Name assigned to New Feed: ______________________________

| Int. Ref. No. | 0-00-101 | 0-00-102 | 0-00-103 | 0-00-104 | 0-00-105 | 0-00-106 | 0-00-107 | 0-00-108 | 0-00-109 | 0-00-110 | 0-00-111 | 0-00-112 | 0-00-113 | 0-00-114 | 0-00-115 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Concentrate | | | | | | | | | | | | | | | |
| Forage | | | | | | | | | | | | | | | |
| Mineral | | | | | | | | | | | | | | | |
| Dry Matter %AF | | | | | | | | | | | | | | | |
| Fat %DM | | | | | | | | | | | | | | | |
| Ash %DM | | | | | | | | | | | | | | | |
| NDF %DM | | | | | | | | | | | | | | | |
| Lignin %NDF | | | | | | | | | | | | | | | |
| ND Insoluble Protein %CP | | | | | | | | | | | | | | | |
| AD Insoluble Protein %CP | | | | | | | | | | | | | | | |
| Crude Protein %DM | | | | | | | | | | | | | | | |
| Solubility %CP | | | | | | | | | | | | | | | |
| NPN (A) %CP | | | | | | | | | | | | | | | |
| Starch (B1) %NSC | | | | | | | | | | | | | | | |
| Net Energy (L) MCAL/LB | | | | | | | | | | | | | | | |

| Int. Ref. No. | 0-00-101 | 0-00-102 | 0-00-103 | 0-00-104 | 0-00-105 | 0-00-106 | 0-00-107 | 0-00-108 | 0-00-109 | 0-00-110 | 0-00-111 | 0-00-112 | 0-00-113 | 0-00-114 | 0-00-115 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Calcium %DM | | | | | | | | | | | | | | | |
| Phosphorous %DM | | | | | | | | | | | | | | | |
| Magnesium %DM | | | | | | | | | | | | | | | |
| Potassium %DM | | | | | | | | | | | | | | | |
| Sulfur %DM | | | | | | | | | | | | | | | |
| Sodium %DM | | | | | | | | | | | | | | | |
| Sugar (A) Digestion Rate %HR | | | | | | | | | | | | | | | |
| Starch (B1)Digestion Rate %HR | | | | | | | | | | | | | | | |
| Avail.NDF(B2) Digest.Rate %HR | | | | | | | | | | | | | | | |
| True Prot.Degrad. Rate(Fast) %HR | | | | | | | | | | | | | | | |
| True Prot.Degrad. Rate(Med.) %HR | | | | | | | | | | | | | | | |
| True Prot.Degrad. Rate(Slow) %HR | | | | | | | | | | | | | | | |
| Rumen Passage Rate %HR | | | | | | | | | | | | | | | |
| %CP From Corn Sources %CP | | | | | | | | | | | | | | | |

Other Agricultural Economics Research Publications

| | | |
|---|---|---|
| No. 90-15 | A Social Accounting Matrix for Cameroon | Madeleine Gauthier<br>Steve Kyle |
| No. 90-16 | An Analysis of Consumer Trends and Employee Training in the U.S. Industry | Gene German<br>Gerald Hawkes |
| No. 91-1 | The Feasibility of Producing and Marketing Fresh Vegetables in Central and Western New York | Raymond Barnes<br>Gerald B. White |
| No. 91-2 | 1991 Budget Guide Estimated Prices for Crop Operating Inputs and Capital Investment Items | Darwin P. Snyder |
| No. 91-3 | Meeting the Need: A Summary and Evaluation of NY FARMNET | John R. Brake<br>Bill Phelan |
| No. 91-4 | U.S. Commodity Promotion Organizations: Objectives, Activities, and Evaluation Methods | John E. Lenz<br>Olan D. Forker<br>Susan Hurst |
| No. 91-5 | Dairy Farm Management Business Summary New York | Stuart F. Smith<br>Wayne A. Knoblauch<br>Linda Putnam |
| No. 91-6 | The Budgetary Implications of Reducing U.S. Income Inequality Through Income Transfer Programs | R.N. Boisvert<br>Christine R. Ranney |
| No. 91-7 | Annotated Bibliography of Generic Commodity Promotion (Revised) | Susan Hurst<br>Olan Forker |
| No. 91-8 | Geographic Price Relationships Under Federal Milk Marketing Orders | Andrew Novakovic<br>James Pratt |