Phase I Study

Design for a Statistical/Epidemiologic Study of Bovine Performance Associated with the CPA/UPA High Voltage Direct Current Powerline in West Central Minnesota

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INTRODUCTION

The historical background of the controversy over the siting and the possible health effects of the 400 Kv DC powerline in Minnesota are summarized in the Minnesota Department of Health's "Design for an Epidemiologic Study of Health Effects Associated with the CPA/UPA High Voltage Direct Current (DC) Powerline in West Central Minnesota" (Dean 1981). The line runs 440 miles from the Coal Creek power generating plant near Underwood, North Dakota to the Dickinson converter station in Wright County, Minnesota. The Minnesota portion of the line is 176 miles long and it runs through portions of Traverse, Grant, Stevens, Pope, Stearns, Kandiyohi, Meeker and Wright Counties. The line's rated capacity of 1000 megawatts. For the purposes of this study, the initial date of operation (charging) of the line was October 17, 1978.

The literature on the possible biologic effects of the DC fields and air ions is growing, although it is not as extensive as that of alternating current (AC) fields. Much of the literature on DC fields and air ions is summarized in the Dow Associates' 1981 report, "Biological Effects and Physical Characteristics of Fields, Ions and Shock." While both the fields and the ions have been shown to generate biologic responses to laboratory exposures, extrapolations to adverse biologic effects of natural exposure in the power line environment have been more difficult to substantiate.

Many Minnesota livestock producers believe that they have observed signs in their livestock attributable to powerline exposure. In the "Perceptions of Landowners about the Effects of the UPA/CPA Powerline on Human and Animal Health in West Central Minnesota" (Genereux and Genereux 1980), nineteen percent of the producers believed they observed breeding problems; eighteen percent, congenital abnormalities; sixteen percent, stress; and twelve percent believed that a change in milk production could be attributed to the powerline.

The veterinary medical community serving the powerline area in West Central Minnesota generally does not feel that the powerline, per se, has had deleterious effects on the health of livestock. At the same time, veterinarians individually indicate that they do not believe there is enough data to scientifically evaluate the question. Therefore, they have not ruled out the possibility of adverse biologic effects in livestock exposed to one or more of the physical components of the DC line.

In view of the limited applicable data and lack of consensus in the scientific and veterinary medical communities about the possible animal health effects of powerline exposure, and in view of the concerns expressed by livestock producers about the perceived effects on their animals and the potential personal and state economic consequences, it would appear prudent to attempt to evaluate whether observable biologic effects can be demonstrated. The purpose of this Phase I of the animal study is to evaluate whether there are observable biologic effects in the body of accessible data which can be associated with natural powerline "exposure".

The keys to this investigation are the evaluation of natural exposure, the control of confounding variables in the evaluation of associated risk factors, and the use of statistical methods. The great difficulties of extrapolation from the relatively high laboratory exposures, to those incurred in the actual powerline environment have been commented on by many authors. To our knowledge this is the first study to evaluate the existence of biologic effects in a large mammalian population exposed to the environment of a DC powerline. The existence or non-existence of biologic effects due to natural exposure must be known before assessment of a possible biologic hazard can be made. The use of relative risks and the evaluation of risk factors will be used to put the results into an epidemiologic context and hopefully provide additional interpretation.

The use of statistical and epidemiologic methods precludes, from the onset, definitive cause and effect findings. At best, associations (positive or negative) between powerline "exposure" and biologic response will be developed. These associations will be the hypotheses which may lead to scientifically valid conclusions of cause and effect. The utilization of the population-based data will facilitate the evaluation of natural exposure. Although not dealing in causal inferences, the study should provide biologic insights into disease patterns within the bovine population and serve to determine and limit the likely biologic effects of powerline exposures.

Throughout this portion of the protocol the terms "powerline" or "line" should be taken to be synonymous with the CPA/UPA DC powerline.

RATIONALE AND BACKGROUND

This section is intended to provide a common understanding of the statistical/epidemiologic principles, bovine biology and data sources to be used in the animal study. It is not intended as a detailed methodologic discourse. This can be found in the Methods section.

Types of Studies

As indicated above, the format of this portion of the animal study will be statistical with an attempt to place the results into an epidemiologic setting. Two types of epidemiologic studies will be appropriate for the available data. The historical prospective or non-concurrent cohort study will follow a group of animals from a given point in time until the current date of study termination. Various constructs of "exposure" to the line will be developed and the outcome responses to the different levels of exposure will be evaluated. If there were observable biologic effects to powerline exposure, one would expect that as the exposure is increased, the response would be larger or more frequent. For example, one would assume that if there were biologic effects due to powerline exposure that animals in the immediate proximity of the line would demonstrate these effects more consistently than animals several miles distant from the line. In this case, the exposure construct would be distance. It is important to note that no a priori definition of a disease case is being made in this design as well as in the design to be discussed next. Therefore, natural subdivisions into case and control cannot be made and these categories will have to be arbitrarily chosen or determined by statistical comparison.

Another design to be employed is the retrospective study. This study would contrast previous exposure to the line among animals determined to have observable effects to those without them. Again, one would expect to find that exposure was more common among the cases than among the controls if exposure-related disease is suspected.

Whether the observational unit is the individual cow or an entire herd, comparisons cannot be directly made among herds or animals in different herds. A major source of variability encountered in analyzing data from dairy animals is the among-herd variability. Depending on the biochemical or physiologic parameter being measured, up to 60% of the total variability is accounted for by the herd variable (Appendix I). This source of variability probably reflects differences in management practices (DHIA 1978). To minimize the effect of this covariate it will be necessary to use animals or herds as their own "control" in order to measure baseline departures after the charging of the powerline on October 17, 1978.

In addition to management variables there are other potential confounding variables that will need to be included in the analyses. In the context of this study, infectious disease could be a classic confounder. An infectious disease could occur near the line and not be in evidence several miles from the line. Using milk production as an indicator of biologic effect, the infection would distort the proximity to the line (exposure) and milk production decrease (case) relationship. Without knowing about the infection, the drop in milk production near the line which was not occurring distant from the line could be mistakenly attributed to powerline exposure.

Management and disease are but two factors that could confound the interpretation of this analysis. This phase of the animal study will therefore be dependent upon the other phases of the study in order to help prevent confounding and preclude, as much as possible, erroneous inferences and conclusions.

Measures of Biologic Effects

Milk production is one of the more sensitive indicators of any adverse effects that may be occurring in a dairy herd. Generally, a drop in milk production accompanies most clinically obvious and sub-clinical disease (Blood and Henderson 1974, Schwabe 1977). Therefore, changes in milk production are not specific. Factors such as changes in feed quality, environment, movement from barn to pasture, or alterations in normal daily routines as well as specific diseases will initially result in decreased milk production.

Another variable to be employed as a measure of biologic effect is reproductive efficiency. The efficiency of reproduction in domestic livestock depends upon many factors including frequency and detection of estrus, number of ovulations, duration of pregnancy, age at puberty and duration of the reproductive period in an animal's life. Thus, reproductive efficiency can change as a result of managerial, seasonal, genetic, nutritional, hormonal or other pathologic factors leading to either partial or complete reproductive failure. In addition, reproduction is also closely linked with milk production so that on a herd basis an agent that causes an effect on one may well result in indirect effects on the other. As with milk production, reproductive efficiency is a sensitive but not specific indicator of bovine physiologic integrity. This lack of specificity of reproductive efficiency re-emphasizes the dependence of this phase of the animal study upon management and clinical information for help in distinguishing between the effect(s) of powerline exposure and biologic responses to other stimuli.

In addition to sensitivity of response, production and reproduction changes may have deleterious effects. All biologic effects are not of themselves representative of pathologic changes. For example, an "exposure" to temporary water withholding will cause a biologic effect of increased urine concentration. This is not a pathologic change but a physiologic response, consistent with normal homeostasis. Changes in production and reproductive efficiency may be part of a homeostatic mechanism, but their existence impacts directly upon the livelihood of the dairymen in whose herds the changes of performance occur and therefore provide a meaningful end point for study.

Bovine Lactation Cycle

The dairy cow becomes sexually mature between nine months and one year of age. Her estrus cycle averages about 21 days between ovulations. She is usually first bred at about 15 months of age. The average gestation period is about 280 days at which time she starts her first lactation.

The normal lactation curve for production is given in Figure 1. The portion of the curve to the maximum production at 1 1/2 to 2 months post partuition is extremely variable among cows (McDaniel et al 1967). After the time of maximum production, the next 7 to 8 months of lactation are represented by linear descent to the lowest production levels (Illinois 1981).

In routine dairy practice the dairy cow is bred again between 60 and 120 days after calving. Forty to seventy days prior to the next expected calving she is "dried-off". This means that the current lactation is terminated. Usually the drying-off occurs during very low levels of milk production (Figure 1). This period serves as a resting period to allow her to gain the energy and the physiologic conditioning required to support the next lactation effort. This cycle is repeated as long as the cow maintains her productivity. To put into perspective the metabolic demand of lactation, an average dairy cow reproduces her body weight in milk ten or more times during the course of each of her lactations.

The sequence of events in the bovine lactation cycle is summarized in Figure 2.

Dairy Herd Improvement Association Data Base

The data upon which the statistical portion of the animal study would be based is that derived from the Minnesota Dairy Herd Improvement Association (DHIA) records. The DHIA program is a national dairy records-keeping plan whose organization includes participants from the private sector and government at both the state and national level. The purpose of DHIA is to provide each member dairyman a wealth of management information on his herd. The data from the DHIA are of high quality, are consistent, and are comparable among the various regions. The details of this data source are found in Appendix II.

METHODS

The purpose of this section is to describe the methods that will be used to evaluate the presence or absence of associations between powerline exposure and observable biologic effects in the dairy cow.

The analyses will use the individual animal and the entire herd as observational units. The individual animal studies will explore the relatively longer term (chronic) effects of the powerline on the DHIA records of milk production for entire lactations, and the chronic effect on calving intervals. The acute effects will be examined by analyzing the trends in recorded production during the lactation in which the line was initially energized.

The analyses using the entire herd as the observational unit will be similar to the individual cow analyses in order to measure the chronic effects on a herd basis. In addition, the culling (reasons for animals leaving herd) distributions will be compared before and after the initial energizing date to evaluate the impact of selection on the remaining animals.

When appropriate, the statistical analyses will be structured to give the relative risk estimates and evaluation of risk factors usually encountered in epidemiologic studies. Also, all evaluations will be made in comparison to other suitably "non-exposed" groups and efforts will be made to preclude confounding by tertiary variables.

Description of DHIA Data Base

There are 553 dairy herds within ten miles of the powerline that are currently in the DHIA program (Table 1). The current average herd size is

43.9 animals. Forty of the 553 herds are owned by dairy operations that have a powerline easement on their property. If the average productive life of a dairy cow is four years and if she is producing milk ten months a year, then we would expect to find about a quarter million previously collected data points on the milk production of animals within ten miles of the line that were in dairy herds when the line was charged on October 17, 1978. All the 305 days and completed records have been maintained and the individual projected records back to April 1978 have been retained on magnetic tape at the Dairy Records Processing Center (DRPC) in St. Paul.

The individual cow report (Appendix III) contains sample day data, date of last calving, lactation number, days dry, lactation to date summaries, projected 305 2xME records, reproduction, 305 day and completed records, and indications of reasons for infertility, poor production, or removal from the herd that will be useful in this study.

The herd summary report (Appendix IV) contains rolling herd averages for production parameters and other production summaries including crude energy indices that could be utilized as covariates in the study.

General Qualifications for Inclusion in Study

Specific qualifications for inclusion in the study designs will be given for each analysis. There are however, general qualifications for inclusion of a farmstead in this phase of the animal study. They are:

1. DHIA member
2. Signed release
3. Within 10 miles of the powerline

4. Holstein herd

5. Utilized twice-a-day milking practice

(The loss in the 553 DHIA herds on the basis of not qualifying under 4 and 5 above is expected to be very small.)

The signed release is required to obtain the data from the DHIA and response to this request may not be uniform nor can initial complete compliance be expected. In conjunction with local veterinarians and extension services, the College of Veterinary Medicine will attempt to maximize the yield of positive responses. Several written and personal contacts will be used and the communication process will continue until a response has been generated. Additional effort will be used to gain the confidence and permission of dairymen whose initial response will be negative. It is currently believed that only a small percentage will not respond to the confidential use of their records by the College of Veterinary Medicine.

Since the data are already collected and are accessible at a very low marginal cost, the sample size for the various portions of the study has been determined to be all the animals that qualify. The number of potential qualifying herds on property physically containing the powerline is 40. This would be the smallest stratum used in the study. Based upon routine simplifying assumptions, the expected number of animals in this stratum is quite adequate (power greater than 95 percent probability) for establishing 20% differences in group responses as highly statistically significant. (A 20% change (drop) in milk production is the maximum that we could expect to observe.) Over half of the population of 553 herds would have to be unusable before the 0.95 power level could not be maintained (assuming no confounding relationships between record use, "exposure", and changes in production).

Exposure

Exposure to ions and DC fields will be by proxy vaiables. Exact measurements at each farm are not now nor were they historically available. Of all the constructs available, distance appears to be one of the easiest to measure. Distance also is easily interpretable in a biologic context. If there is an effect of powerline exposure then we would expect to see a dose-response relationship. Translated to the present study, the existence of distance-response association would be interpreted as consistent with a dose-response relationship.

There are three continuous measures of exposure related to distance from the powerline that will be constructed for this study. The first is the perpendicular distance (or distance to the point of closest approach) from the powerline to the dairy operation. Most Minnesota dairymen practice fairly confined operation of their dairy herds and measurement from the point of dairy operation to the powerline will approximate the average distance of the cow from the line. Aerial maps demonstrating relative position of barn and line will be used to calculate the perpendicular distance.

The distance to the point of the closest approach of the line may not be a good approximation of exposure if there are strong prevailing winds. Therefore, distance along prevailing winds from the line to the dairy operation will be measured. Area wind roses superimposed on the aerial maps will be used to calculate the distance along the wind vector. If prevailing winds change seasonally,then different measurements will be needed to reflect these changes. If the farm is down-wind, this distance exposure will be heavily weighted. If the farm is upwind, the distance exposure will be lightly weighted. Expert meteorologic counsel will be used to model exposure when the prevailing winds from the line do not intersect the farmstead.

To facilitate initial analyses and to utilize the techniques of categorical data analysis (i.e., log-linear models), four discrete distance-related exposure strata will be set up. They will be:

1. dairy operation within to-be-determined minimum distance from line.*
2. dairy operation outside of above distance but within one mile of line.
3. dairy operation within 5 miles but greater than one mile from line.
4. dairy operation within 10 miles but greater than 8 miles from line.

Stratum four can be viewed as the absolute control with no biologic effects believed to occur at this distance from the line.

Suggested Analyses

General

Since the owner-sampler plan (as contrasted to the official plan) data are used only for the individual dairyman's herd management, the validity of this data should be comparable to that of the official plan. Through preliminary covariate analysis, the acceptability of this hypothesis can be tested. If the results are not plan dependent, then this variable can be dropped as a covariate. If there are significant differences, then this variable will have to be retained.

Multivariate linear statistical methods will be used to detect the nature of differences (if any) in individual animal performance immediately before and after the powerline was turned on. Parallel analysis will be done in all four strata and the results compared. The multivariate approach and the use of each animal as its own control are expected to aid in accounting for as

*Minimum distance to be determined by a physical survey of study farms many confounding variables as can be determined. To the extent that exposure factors can be approximated by the distance constructs, the degree of animal response will be correlated with exposure. Statistical inference will be directed toward detection of a significant relation between performance and exposure.

Profiles of herd performance will be drawn over a number of years before and after the powerline was energized. Comparisons will be made between the levels of "exposure" using the herd as its own control. Relevant factors such as management indices and infectious disease history will be accounted for, when available, in the comparison of the herds. The herd analyses as companion to the individual cow analyses are necessary to evaluate whether the observable effects are animal and/or herd dependent. Also, the comparison of the multinomial distribution of stated reasons for culling between proximity groups can only be done at the herd level.

Individual Animal Studies (Chronic)

The portion of the study using the individual animal as its own control will attempt to evaluate the chronic and acute effects on bovine production and reproduction. To be eligible for the chronic production study the animal must have had at least one completed lactation before October 17, 1978 and at least one completed lactation after this date. This will allow the use of the 305 2xME records which adjust for differences in age and month of calving. To be eligible for the reproduction portion of the analysis of chronic effects the cow must have had a second calf before October 17, 1978 and at least one additional calf after the date of line charging, or at least three calvings with the birth of the second calf within 80 days of the line charging and the second calving considered to be normal. The calving interval, the time between calvings, can then be constructed for each animal before and after line charging. To increase the number of animals eligible, the charging of the line in the third trimester of a particular pregnancy will not preclude counting that calving interval in the before-charging category if the calving was considered normal. The calving interval is a sensitive but non-specific indicator of reproductive efficiency. It is easily measured from the data available and will be used to evaluate the existence of reproductive effects due to powerline exposure.

The milk production parameters to be used are pounds of milk, pounds of fat and fat corrected milk (FCM). FCM is defined as: (pounds of milk)x0.4 + 15x(pounds of milk)x(percent of fat). FCM is a hybrid of pounds of milk and fat and it is viewed as a means of adjusting to a common metabolic equivalent (Cambell and Marshall 1975).

Multivariate linear statistical models will be used to evaluate differences in production and reproduction among the four strata. The distance criterion for the strata will be the distance to point of closest approach of the powerline to the barn. Each animal will serve as its own control and the period prior to line charging will serve as the baseline from which departures will be measured. Since the production parameters will be from completed or 305 day 2xME records, they will be adjusted for age and season of calving. Other covariates will have to be included in the analyses. Days open and days dry for the specific lactation are known to have an effect on production (Schaeffer and Henderson 1972). Management proxies will include herd size, DHIA twelve month rolling herd average for milk production and other management proxies as may be deemed reasonable for each lactation period. These management evaluations will come from the DHIA records or the Phase II management survey.

To expand the examination of the existence of relationships between exposure and response variables, the continuous distance measures will also be employed. Multivariate methods will be used to correlate the production and reproduction response variables to the continuous measures of exposure using a similar set of covariates as already described above. In addition to the combination of continuous distance measures previously described, it will be informative to look at the analyses specific to the downwind and the upwind positions in order to overcome the lack of biologic symmetry in these exposures.

To put these relationships into an epidemiologic context and to evaluate the existence of association between exposure and biologic effect, a set of "cases" can be derived from the preceding analyses. Any animal which is at the periphery of the distribution of these effects after accounting for the covariates can be considered a "case". The definition of peripheral would probably be the upper and lower five or ten percent of these distributions. Since it is the goal of this study to evaluate the existence of biologic effect, animals that have had significant (relative to other animals in different strata and relative to their previous history) <u>increases</u> in production or reproductive efficiency after the line was charged are also of interest. One of the proposed elements of the response to exposure to DC lines is increased serotonin levels and this neurohormone could increase milk production (Sulman 1980).

Another set of "case" definitions may also be useful. Instead of linking the definition to relative performance in the various strata which are potentially exposure dependent, absolute changes from a baseline level can be used. Animals which experienced ± five percent, ± ten percent, ± fifteen percent changes or ± twenty percent changes over a given time period after line charging could be considered as "cases". For each case subset the remaining animals in the data base would serve as controls.

The evaluation of the effect and the relative importance of other parameters on the disposition of case and control status can be estimated from discriminant analysis. Multiple logistic regression and log-linear models will be used to detail the multivariate structure of the relationships and to evaluate the approximate relative risks associated with various levels of the other previously described variables. Confidence intervals for the approximate relative risks will be constructed and the evaluation of management and exposure constructs as risk factors will be conducted. The variables previously identified as being related to both exposure and outcome will be considered as confounders. Their effects will be minimized by application of stratification procedures and inclusion of these variables in the multivariate models.

Individual Animal Studies (Acute)

The literature on the potential effects of air ions and DC fields indicate that relatively quick responses are observed in the laboratory (Sigel 1979). It is possible that if there were effects of exposure that a tachyphylaxis could develop and the evaluation of the longer term (chronic) exposures would be somewhat misleading. Also, the evaluation of chronic effects are dependent upon management and clinical parameters that may not be adequately controlled.

The study of the acute effects of exposure to the powerline will evaluate the production performance in the lactation in which the powerline was initially energized.

The segment of the individual lactation curve from three months to the dry period (at about ten months) is predictably linearly decreasing in this interval (Figure 1). The qualifications for animals to be included in this portion of the study are that they be in their sixth or seventh month of lactation at the date of initial line charging (October 17, 1978). This will permit three months of observation in the straight line period (after the third month) before line charging and three months of observation after this date before the onset of the dry period. Although this definition of eligibility appears to be restrictive, there are more than adequate numbers of qualifying animals to guarantee statistical power.

The design of this portion of the study requires three months of milk production data (FCM, pounds of milk and pounds of fat) to predict the next three months of production after line charging. The distributions of deviations from the projected values will be compared among the four strata. Since the covariates being included in the chronic individual study are not likely to vary substantially in the six month interval of this analysis their inclusion in the multivariate models may not be necessary.

Herd Studies (Chronic)

The analyses of the chronic effects on individual animals will be repeated using the herd as the observational unit. The herd values before the line charging will be used as a baseline from which to measure departure after the line was charged. These deviations will be contrasted among the strata using multivariate profile analysis (Morrison, 1976). Rolling herd averages for production will replace the individual lactation results and average calving intervals will replace the individual calving intervals. Since the rolling herd averages may not be as sensitive as the individual records and the other herd constructs of performance determined at arbitrary times may not be as biologically meaningful as completed lactations, the use of case-control methods to evaluate risk factors will not be employed. The purpose of the analyses to evaluate the statistical significance of herd performance will be to compare these results to those found in the individual animal study. It will be important to determine if the existence of chronic individual animal effects translate to the total herd since it is only at the herd level that retrospective management and disease histories can be developed.

Dairymen are sensitive to decreases in milk production. There may have been a strong selection pressure to eliminate animals that had a significant drop in their milk production. These could have been the animals that were responding to an element of the powerline environment. If this pressure was systematic and persistent, the survivors may give a biased picture of the potential for biologic effects. The reasons for animals leaving the herd (culling) can be obtained from the DHIA records. Multinomial distributions of reasons for culling will be constructed from these records. The proportion of the animals removed from the herd prior to the powerline energizing for poor performance, infertility, disease, etc., will be compared to the similar distributions after the line was energized. Deviations from homogeneity of these various proportions will be compared among the strata. If significant increases in the proportion of the animals culled for poor production or reproductive problems are to be attributed to powerline exposure, then the increased culling for performance reasons should not be seen in the more distant strata. If culling is not to confound the other analysis, then the multinomial distributions over time should be similar among the various strata.

CRITIQUE

The purpose of this section is to provide a critique of the methods to be used in the statistical/epidemiologic study of animals in the vicinity of the DC powerline. It is important for the authors to indicate what they believe are the major strengths and weaknesses of this protocol as they initially have the best insights into how the study will unfold. These insights should help other readers internalize the methods and therefore provide them with a basis of detecting additional strengths and weaknesses that were not envisioned by the authors.

The major strength of this study is its basic design of evaluating the effects (if any) of natural exposure to the DC line environment. For a data base, the study will draw upon (tens of thousands) previously collected data points. All of these data were collected under the standardized and long established protocol of the DHIA. Since both the official and owner plan data were collected before involvement in a powerline study was contemplated, they should be free of observer bias.

The current knowledge about the factors that are associated with bovine production and reproduction adds great strength to the study. There are major factors that need to be controlled. Season of calving and age at calving have a very strong influence on expected production levels. The effects of these variables are standardized to common values in the DHIA system. The number of days open and the length of dry period also influence milk production. These variables will be used as covariates and stratifying variables.

Other aspects of the general management variable are very important to the sensitive but non-specific response variable of milk production. Several proxies have been put forth. One of the best is the rolling herd milk production average. The bottom line of any management evaluation is performance. All factors that could impinge upon milk production are translated into herd milk production averages. The use of the other management constructs and the Phase II management and clinical surveys to obtain other management indices associating management practice and powerline existence should help control this important source of confounding. Also, the basic design of using animals or herds as their own baseline controls should help limit the impact of management differences that were not a result of systematic changes associated with the powerline. Although these latter management influences cannot be viewed as potential confounders, the dependence of milk production upon management parameters is so large that this major source of variability must be controlled whenever possible.

Selection bias could play a role in this study at several levels. The individual dairymen have determined their participation in the DHIA. This self-selection for inclusion in the program might make generalization to all the dairy practices difficult. However, the number of herds and animals involved in the DHIA program is large enough to insure that any conclusions drawn from the study will have scientific validity.

It is hoped that almost all of the candidate DHIA members will elect to participate in this study. The size of the numbers is such that more than fifty percent of the DHIA members may decline participation and we would still have adequate sample sizes for statistical precision. However, a biased and non-uniform response will seriously jeopardize the validity of this study. If the expectation for participation is not met, methods for evaluating the similarities of the participating and non-participating DHIA members will have to be developed. This may be very expensive and a premium will be placed upon acquiring the participation of those initially declining to participate. It is anticipated that the auspices of the College of Veterinary Medicine will promote satisfaction of the participation expectation.

Although observational bias should not be a problem with the DHIA data, it may be impossible to blind the Phase II management survey team to the dairymen's proximity to the line. If this cannot be done, then one of the elements of the management index covariate could be biased toward "management changes" near the line. This would serve to diminish the study's capacity to detect differences that were biologic responses to the DC environment.

The importance of management factors to the response variables has been repeatedly emphasized. Several methods of accounting for the influence of changes in management have been indicated. Where management changes were not related to the proximity of the powerline these changes cannot be considered as classic confounders. However, the statistical determination of differences in bovine performance will have to effectively account for this major source of validity. Where changes in management are associated with proximity to the powerline (i.e., use of easement money to "improve" dairy herd), the management set of variables could drastically confound the evaluation. Therefore, if the methods for controlling or estimating these variables are not effective, the utility of the analyses will be limited.

The exposure constructs may be weak. It is believed that humidity, and season, wind direction, terrain, soil composition, barn construction and distance are important to the potential exposure to the DC line. This study will attempt to use distance and prevailing wind direction as the elements of exposure constructs. Where comparison will be made over long periods, season can be controlled by appropriate statistical techniques. Whether these measures of exposure will be adequate is not known. A comparison of the results derived from the perpendicular measures and the wind directed measures of exposure may give us insight into how robustly "distance" can be viewed as a measure of exposure.

In the context of translating these analyses into case and control studies, the process of case definition is not well defined. We do not have a clinically defined end point that will yield a case definition. Instead, analysis of the data will detect outliers to be called cases, and arbitrary definition of the percentiles for case classification will be used. It is important to maintain a definition of cases that is unbiased by the herd's distance from the line. On the other hand, the control groups -- the residual of the entire DHIA population not considered cases -- will be comparable to the cases for many factors. This will facilitate good contrast between the factors that are important to the case status and should, if it exists, bring out the dependence of case status upon the exposure constructs.

It is clear that there are a number of variables that need to be included in this study. Whenever knowledge about the variables important to an outcome increase, the potential for precise studies of the outcome increase. This precision is accompanied by technical complexity. The number of variables that we will attempt to simultaneously analyze is large. The multivariate linear statistical procedures are sensitive to dependence within the presumed set of independent variables or covariates. Determination of the variables that need inclusion and best represent the sources of variability can be difficult and time consuming.

Another source of technical difficulty is that the records at the DRPC are not designed for this kind of study. It will take a major effort to compile a sub-file of all the requisite information on all the DHIA herds to be included in this study. This data now resides on 156 reels of magnetic tape. It is believed that the technical and the theoretical problems associated with this study can be overcome. The quality and quantity of the data is believed to be sufficient to detect the existence of bovine biologic responses to the DC environment of the CPA/UPA powerline.

Table 1 - Number of DHIA Herds Within 10 Miles of Powerline by County

County	Number of Herds
Grant	31
Kandiyohi	15
Meeker	137
Pope	42
Stearns	234
Stevens	0
Todd	3
Traverse	4
Wright	87
TOTAL	553

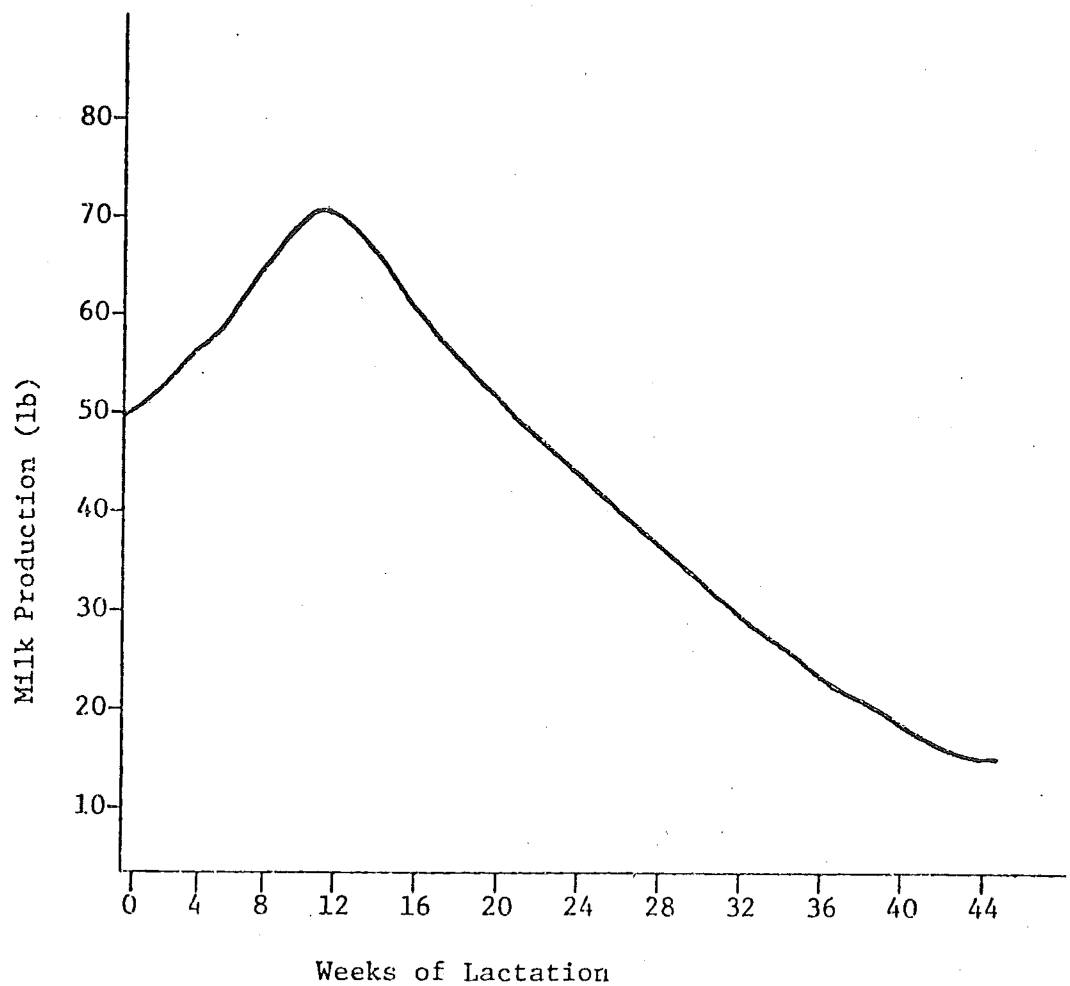

Figure 1 - Milk Production During Typical Lactation

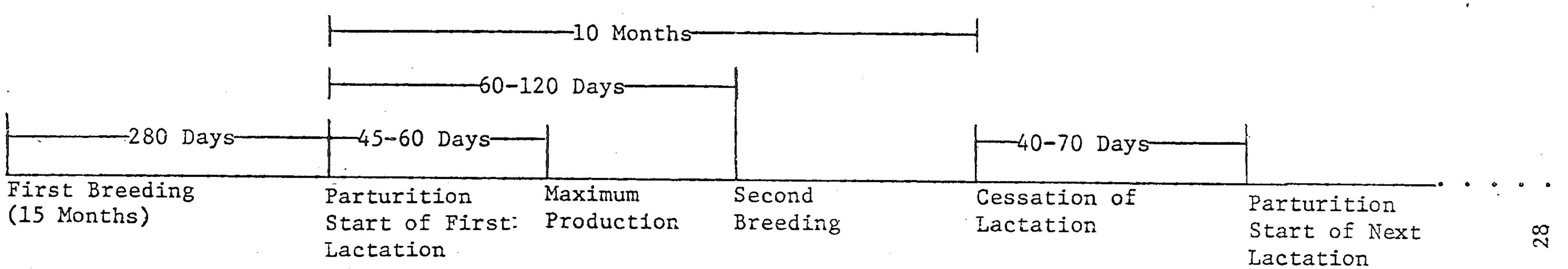

Figure 2 - Events in Normal Bovine Lactation Cycle

APPENDIX I

Intraclass Coefficients* (R^2) of Herd Variable to Total Variability for Various Parimeters+

Parameter	R^2(%)
pounds of milk	13.8
percent fat	8.5
packed cell volume	23.7
hemoglobin	22.1
red cell count	25.4
mean corpuscular hemoglobin	44.2
mean corpuscular volume	39.0
mean corpuscular hemoglobin concentration	23.0
white cell count	26.2
lymphocytes	18.1
total neutrophils	18.1
eosinophils	10.8
basophils	7.1
monocytes	22.8
glucose	54.2
blood urea nitrogen	60.0
cholesterol	23.3
sodium	44.0
chloride	26.9
magnesium	39.1
calcium	40.3
phosphorus	40.3
potassium	26.5
alkaline phosphatase	28.4
total serum protein	19.3
albumin	43.4
globulin	21.8
SGOT	38.5
CPK	53.0

*Intraclass coefficients or R^2 are defined as the ratio of between herd's sum of squares to the total sum of squares for that parameter. For example, for BUN, herd sum of squares = 30360.62 and sum of squares total = 50562.6313 and the ratio is 0.60. This is interpreted as sixty percent of the total variability in BUN being attributable to the herd variable.

+Data obtained from Metabolic Profile Testing Program of 38 Hostein herds and 1508 animals. Supported by the Minnesota Agricultural Experiment Station Grant No. MN 20-047.

APPENDIX II

The Official DHIA Plan is the most widely used dairy record-keeping plan with over two million cows enrolled nationwide. A DHIA Supervisor visits each enrolled herd approximately once per month. The DHIA Supervisor records each cow's milk yield at two consecutive milkings (to measure 24-hour yield), takes a sample of milk from each milking which is composited and tested for milk fat and content at a central testing laboratory, enters all the required data (calving dates, dry dates, etc.), and sends them to the Dairy Records Processing Center (DRPC) serving that area of the country. The DRPC that serves Minnesota dairymen is located at the University of Minnesota. After the data is computer-processed at the DRPC, it is returned to the farm for the dairyman's use, about a week after the DHIA Supervisor's visit.

The Owner-Sampler Plan is similar to the Official Plan except the dairyman weighs and samples the milk rather than the DHIA Supervisor. Consequently, owner-sampler yield data is not considered "Official" and is for within-herd management purposes only.

The calculation of yield data for DHIA is according to a national set of DHIA rules to ensure that an individual cow will be assured the same record no matter which DRPC calculates the record. The most important single phenotype of a dairy cow is her milk yield. To compare the yield of different cows, the yield is put on a standard basis.

The standard length for a lactation is 305 days. When cows milk longer than 305 days, their yield for the first 305 days is taken as the lactation yield. The 305-day record is traditionally standardized to a Mature Equivalent (ME) basis labeled as 305 2xME record on DRPC returns to the dairyman. The correct interpretation of an ME record is: the amount of milk or components that the same cow would have produced if she had calved in an environmentally average month and been of mature age. The age and month of calving adjustment factors used in the United States were published in 1974 (Norman 1974). These factors were developed from a national set of DHIA lactation records using statistical procedures that estimated the effects of both age and month of the year at calving on the amount of milk and milk fat that cows produce.

In addition to the mature equivalent standardization for differences in age and month of calving, animal production records in progress are projected by the DHIA to 305 days using standard factors (McDaniel et al 1965). The reliability of projected records increases as the number of days of observation increase. Records terminated by a cessation of lactation (dry period) prior to 305 days are considered complete records and are not projected. Records terminated by cows leaving the herd are projected to 305 days. As seen in Figure 1, the quantity of milk production is dependent upon the month of lactation. The projection of the amount of production to date is an attempt to standardize for the different months of lactations. These projected records are then standardized for mature equivalency and are referred to as projected 305 ME records.

The estimates of monthly production based upon two milkings in a single day was compared to the actual monthly productions. The correspondence between the observed and estimated production was excellent. The correlation between these values exceeded 90%.* Therefore, the DHIA estimates are believed to be a good representation of true production and are accurate enough to justify the intended comparisons of this study.

*Personal communication from Dr. Gerald Steuernagel, Dairy Extension, University of Minnesota

APPENDIX III

Example of DHIA Individual Cow Report

JOHN DAIRYMAN 101 HAECKER HALL ST PAUL MN 55108 1209

HERD CODE	TYPE OF RECORD	ASSOC	SUPVR	LAB	CO	SC DAY	TEST INTERVAL	LA… TE	RECEIVED	MAILED	BREED	MATURE WT	NO COWS	INTERVAL	SAMPL… ATE	RPT	PAGE
41-00-0067	FFICIAL DHI	62	1	1	62	22	12-03 1-05	.6	1-07	1-14-79	HOL	1300	28	34	1-..-79	56	1

DAIRY HERD IMPROVEMENT
DHI 200
5-78

COW REPORT

INDEX NUMBER	BREED	PERMANENT IDENTIFICATION OF COW	COW'S SIRE	LAST MILK LBS	SAMPLE DAY DATA MILK LBS	% FAT	INCOME OVER FEED COST $	MASTITIS	LBS TO FEED GRAIN	PROT % 44	BARN NAME	DATE CALVED	LACT NUMBER	AGE AT CALVING	DAYS DRY	LACTATION-TO-DATE DAYS IN MILK	MILK LBS	% FAT	FAT LBS	PROJECTED 305-2X-ME MILK LBS	FAT LBS	PROD INDEX	TIMES BRED	REPRODUCTION DUE DATE	SERVICE SIRE	REMARKS (OVER)
0025	H	41XHI1201	17H268	52	58.1	3.7	4.86	1	21		ANGIE	11-10	4	4-11	54	57	2881	3.7	106	10985	385	79		OPEN		
0023	H	41XGN5652	29H2296	39	30.4	3.8	2.32	2	9		ARLENE	8-15	4	4-11	45	144	7095	4.4	315	12622	568	102	1	8-23	21H415	
0062	H	41AZG2357			56.0	3.5	4.43		21		AUGUST	12-20				17	771	3.0	30							N
0008	H	41XFC8011	29H2346	34	33.8	4.2	2.79	3	11		BETSY	6-29	8	10-00	133	191	7426	3.8	282	11028	425	80	3	9-08	21H318	
0029	H	41WGG0870	21H232		68.1	3.9	5.85	N	28		BETTY	11-29	3	4-09	72	38	2329	4.3	100	14873	533	112				
0041	H	41WFG1725	17H348	64	63.3	4.0	5.55	T	24		BLUE	9-28	4	5-09	67	100	6014	4.0	239	14219	550	107	1	9-14	21H369	
0026	H	41WFW3625	....		FRESH						BONNIE	1-04	4	5-00	93											
0021	H	41AZD3871	17H240	17	49.5	5.2	4.81	N	22		CANDY	2-04	3	4-09	95	336	16316	4.6	757	15088	694	116	4	9-16	21H417	
0031	H	41WFL1210		24	20.3	3.7	1.36	1	4		CAREY	11-06	3	3-10		51	1326	3.8	51	4977	181	34	1	9-03	21H266	A
0037	H	41WFP6996	21H232		39.0	4.0	3.17	1	14		CARLA	12-04	3	4-00		33	1133	4.4	50	8761	320	63				A
0046	H	41WFP6997	21H232		83.5	4.1	7.38	T	36	1	CHRIS	12-03	2	4-01	42	34	2527	4.5	114	18793	709	152				
0042	H	41WFW3608	21H224	47	59.9	3.9	5.14	T	23		COOKIE	11-03	2	3-07	33	64	3079	3.3	116	11230	402	82	1	10-08	21H396	
0038	H	41WFL1168	21H206		70.3	3.9	6.06		29		CUTIE	12-19	3	4-04	67	18	1038	4.2	44	15633	551	118				
0014	H	41AXX1568	21H246	39	35.1	3.5	2.66	N	10		DAISY	4-06	4	6-04	50	275	15076	3.4	517	15815	548	107	1	P 3-31	21H240	D
0052	H	41XHC4949		29	26.4	4.3	2.12	1	7		DARLEN	2-20	5	4-01	7	320	17326	4.2	722	17260	719	127	5	6-26	21H371	
0059	G	41C135246	21G237	31	25.2	4.7	2.18	3	11		DAWN	10-02	1	2-11		96	2737	4.4	120	7710	348	60	1	9-15	21H319	
0058	X	41XIE9996		30	26.3	5.1	2.34	1	8		DIANE	9-21	1			107	3439	4.4	150				1	8-25	21H415	
0057	H	41WGG0863	17H365	46	50.7	3.1	3.83	2	19		DIXIE	8-03	1	2-00		156	7384	3.0	223	16551	494	113	1	7-09	21H268	
0044	H	41WFG8083	29H2188	50	50.9	3.3	3.96	T	17		DONNA	5-29	6	7-04	86	222	13070	3.5	453	16118	575	119	1	P 5-17	21H408	
0060	H	41CAH8566	17H240	40	40.1	3.1	2.93	N	15		DORY	10-20	1	2-00		78	2815	3.6	100	11359	393	81	1	10-06	21H386	
0048	H	41AZD0298			51.5	4.1	4.39		21		DUSTY	12-15	3	4-11	39	22	952	4.5	43	11227	416	83				A
0007	H	41AVZ3863	21H257	16	16.5	3.9	1.06	2	2		GINGER	3-31	7	8-09	57	281	14109	4.3	602	14820	645	111	1	P 4-08	21H406	
0061	G	41XR81357	29G775		55.2	3.9	4.67	T	26	1	JULY	12-09	1	2-01		28	1298	4.3	56	15005	629	123				N
0045	H	41WBQ9324	29H1895	46	51.4	4.0	4.39	1	19		LIZ	8-07	11	13-01	54	152	7947	3.3	299	15697	604	120	1	OPEN	21H385	
0006	H	41ACE5728	....	41	38.5	3.4	2.94	3	11		MARCH	9-10	6	7-07	70	118	4619	3.2	147	9558	303	62	3	9-25	21H256	
0050	H	41AZD1631	17H255		DRY		-.73		0		MELISA	2-10	1	3-03	40	290	15778	3.6	552	17040	601	116	1	1-16	21H184	
0047	J	41AWZ3658	21J305	19	19.8	5.4	1.78	N	9		PEBLES	1-29	3	5-00	8	342	12489	4.9	607	11447	542	88	3	3-22	21H385	D
0051	H	41XHB4846	29H2345	28	DRY		-.73	1	0		VIOLET	2-13	2	4-01	23	304	16765	3.7	617	17100	629	119	1	2-01	17H251	
****		************	********								305 DAY	AND COMPLETED			RECORDS									********	********	******
0021	H	41AZD3871	17H240								CANDY	2-04	3	4-09	95	305	15240	4.6	701	15088	694	116		305 DAY		R
0037	H	41WFP6996	21H232								CARLA	5-02	2	3-05	59	216	9745	3.9	377	13185	509	98		COMPLETE		C
0040	H	41WGI1964									DANDY	8-04	2	3-09	51	140	4803	3.7	180	9296	348	65		SOLD-PROD		C3
0052	H	41XHC4949									DARLEN	2-20	5	4-01	7	305	16922	4.2	705	17260	719	127		305 DAY		R
0013	H	41AWY8445									SALLY	10-27	6	7-08	88	339	12688	3.1	396	12057	373	77		SOLD		C5
0051	H	41XHB4846	29H2345								VIOLET	2-13	2	4-01		304	16765	3.7	617	17100	629	119		COMPLETE		C

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1. INDEX NUMBER — This is an [illegible] number, assigned when the cow enters the herd, to identify each cow in preparing the report

2. BREED — [illegible] are coded as follows: A = Ayrshire, G = Guernsey, H = Holstein, J = Jersey, S = Brown Swiss, M = Milking Shorthorn, D = Red Dane, X = Mixed, W = Red and White. Goats = first letter of each breed name.

3. PERMANENT IDENTIFICATION — All registered animals are permanently identified by the registration numbers shown on their registration certificates. Grades must be permanently identified by: (1) an official uniform series eartag, two digit state code, three letters, four digits—for example, 41WAA1234 — or (2) a Verified Identification (VIP) number of cows with Verified Identification Certificate.

4. COW'S SIRE — Identification (name or number) of the cow's sire for management use.

5. LAST MILK, LBS — Each cow's last sample day milk weight is listed for easy comparison to the current sample day milk weight. Abnormally large drops in milk weight indicate feeding or management problems. A 10% monthly drop after peak production is normal for mature cows and a 7% drop is normal for first lactation cows.

SAMPLE DAY DATA

6. MILK LBS — This is the total of sample day milk weights for each cow.

7. % FAT — The milk fat test of the cow on sample day.

8. INCOME OVER FEED COST — Income over feed cost equals milk sale value minus feed cost. Milk value is calculated from the milk price and fat differential reported. Feed cost includes forage, indicated grain and protein. Forage amounts are pro-rated to each cow according to her estimated body weight.

9. MASTITIS — California Mastitis Tests (CMT) appear just as reported. Any or all of the following codes may be used. N = Negative, T = Trace, 1 = Suspicious or Mildly Positive, 2 = Positive, 3 = Distinctly Positive. If somatic or leukocyte cell counts are reported, add 5 zeros. For example, a score of 12 would indicate a cell count of 1,200,000 leukocytes per milliliter of milk.

10. GRAIN LBS TO FEED — pounds are calculated as follows:
    a. Total Energy required per day equals
       energy needed for daily milk and test
       plus energy needed for maintenance of body weight
       plus energy needed for growth based on age
       plus energy needed for pregnancy.
    b. Energy required from grain equals
       total energy required per day
       minus energy supplied by forages
       minus energy supplied by lbs protein indicated.
    c. Pounds of grain to feed is energy required from grain,
       divided by the energy in a pound of grain.

11. PROTEIN LBS TO FEED — Total protein required per day is calculated in the same way total energy required per day
    a. Protein required from protein supplement equals
       total protein required per day
       minus protein supplied by forages
       minus protein supplied by grain.
    b. Pounds of protein supplement indicated is protein required from supplement
       divided by protein in a pound of supplement.

Pounds of grain and protein supplement to meet these needs are calculated using the grain mix and protein supplement you are feeding. If protein supplement is not top fed, the protein pounds to feed will show the cows which need extra protein. Add grain and protein to feed for total pounds of grain mix if protein is not top fed. If you do not report any grain fed, the pounds of grain to feed will be calculated using ear dry ear corn. Protein needs will be calculated using soybean meal.

12. PROTEIN % — The percent of protein is listed for the supplement fed. If no protein is top fed, it is calculated for soybean meal (44%).

13. BARN NAME — This is the name or number used to identify the cow in day to day management.

14. DATE CALVED — The calving date is reported.

15. LACTATION NUMBER — Lactation number is the number of calvings. A new lactation begins with calving or if the cow aborted after carrying calf at least 152 days, or with 200 or more days in milk if no breeding date was reported.

16. AGE AT CALVING — Age is calculated from the birth date of the cow to her calving date. If birth date is unknown, age is estimated by the owner when the cow enters the herd.

17. DAYS DRY — For cows in milk it is the number of days dry before last calving. For dry cows it's the number of days from dry date through current sample date.

LACTATION-TO-DATE

18. DAYS IN MILK — The number of days milked from last calving date through current sample date. For a cow with unknown calving date it is the number of days on test.

19. MILK LBS — Accumulated lactation pounds of milk for days in milk indicated.

20. % FAT — Average fat % of milk produced in the lactation equals total fat lbs divided by milk lbs times 100.

21. FAT LBS — Accumulated lactation pounds of fat for days in milk indicated.

22. MILK and FAT — [illegible] lactation-to-date [illegible] are projected to 305 days and standardized to twice daily milking and mature equivalent age (approximately 6-8 years), and adjusted for month of calving differences
    a. Records in progress (up to 305 days) are projected to 305 days using standard factors [illegible] confidence (reliability) of projected records increases as the lactation-to-date days in milk increases. Records terminated by a dry date before 305 days are considered complete 305 day records and are not projected. Records terminated by cows leaving the herd are projected to 305 days.
    b. Mature Equivalent (M.E.) factors adjust for age and month of calving differences. Separate milk and fat factors, designed for the Minnesota region of the U.S., are used for each breed. These factors correct differences in production to an average month of calving (environmental correction). Therefore, M.E. records of mature cows calving in high production months (November to March) may be lower than the actual 305-day production.

23. PRODUCTION INDEX — An index intended to be used as a guide in culling cows. It is based on how a cow's projected 305-2X-ME records ($ value) compare with other cows (herdmates) calving in the same season. The index is expressed as a percent, cows with an index of 100 are near average for the herd. Cows will usually range between 75 and 130 in a herd, with the poorest cows having the lowest production index. NOTE: Cows having less than three herdmates do not have a Production Index calculated.

REPRODUCTION

24. TIMES BRED — This is the reported number of times the cow was bred since the last calving date.

25. DUE DATE — Estimated calving date is based on the last reported breeding date. "P" indicates the cow was diagnosed pregnant. Cows fresh 50 days or more with no breeding date reported are listed as "OPEN".

26. SERVICE SIRE — The identification (name or number code) of the bull to which the cow was reported bred

REMARKS

27. A = Cow aborted or calved 30 or more days prior to the expected due date.
    C = Complete lactation record. The cow has dried off or left herd.
    D = Dry off, a reminder to dry off cows at least 50 days before due date.
    E = Production estimated due to sickness, injury, cow in heat, or missing milk weight.
    H = Did not qualify for production estimate according to Official DHI Rule.
    N = New cow.
    R = Completed 305 day record.
    T = Recommend that cow be considered for mastitis "dry treatment" at time of drying off.
    U = Unofficial record because part of the record was unsupervised.
    X = Record did not start with calving date, therefore no 305 day record will be computed.
    Y = Completed 365 day record (extra charge option).
    ÷ = Abnormal record due to 2 or more consecutive sample days production being estimated, or more than 75 days between 2 sample dates, or "new herd" cows with calving dates more than 75 days prior to first sample date.
    * = Milked 3 times per day sometime during the lactation.
    2 = Sold for dairy.
    3 = Sold due to low production.
    4 = Sold due to reproductive problems.
    5 = Sold due to disease, injury, or other unspecified reason.
    6 = Died.
    7 = Sold due to mastitis or other udder problems.
    8 = Record ended by abortion.
    9 = Sold, reason not reported.

FOR MORE INFORMATION

Contact your local DHI Supervisor, County Extension Director, or write State Extension Dairyman, 101 Haecker Hall, University of Minnesota, St. Paul, Minnesota 55108.

APPENDIX IV

Example of DHIA Herd Summary

HERD CODE	TYPE OF RECORD	ASSOC	SUPVR	LAB	CO	SC DAY	TEST INTERVAL		S DATE	RECEIVED	MAILED
41-00-0070	OFFICIAL DHI	62	1	1	62	22	12-03	01-05	01-06	01-07	01-14-79

AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

J. William Mudge
J. WILLIAM MUDGE
EXTENSION DAIRYMAN

12-08

REPORT 56

OPTIONS
ACTION LISTS
365

JOHN DAIRYMAN
101 HAECKER HALL
ST PAUL
MN 55108

DHI 202
6-76

DAIRY HERD IMPROVEMENT

HERD SUMMARY

SAMPLE DATE	LAB
01-05-79	2.52
NUMBER COWS	COMPUTER
28	7.43
COW-DAYS	TOTAL
	9.95

PRODUCTION, INCOME AND FEED COST SUMMARY

DESCRIPTION	SAMPLE DAY AVG PER COW	DHI ROLLING HERD AVG 12 TESTS
NUMBER COWS	28	30.7
% COWS IN MILK	89	86
MILK LBS	40.0	14059
% FAT	3.93	3.78
FAT LBS	1.57	532
DRY FORAGE LBS	8	100 PCT DM 3049
HAY SILAGE LBS	25	100 PCT DM 3181
CORN SILAGE LBS	18	100 PCT DM 1766
OTHER FORAGE LBS		100 PCT DM 755
GRAIN LBS	14	100 PCT DM 6006
FORAGE DM PER CWT BW	2.0	1.9
ENERGY INDEX	96	115
PROTEIN INDEX	110	119
MILK PER LB GRAIN DM	3.4	2.3
VALUE OF PRODUCT $	4.58	1434
TOTAL FEED COST $	1.29	607
INCOME OVER FEED COST $	3.29	827
FEED COST PER CWT MILK $	3.23	4.32
MILK PRICE PER CWT $	11.45	10.20

MANAGEMENT INFORMATION

SAMPLE DAY FEED	AVG LBS CONSUMED	PCT DM	NET ENERGY	CRUDE PROTEIN	COST $/TON
HAY	8	90	51	15	55
CORN SILAGE	18	27	59	9	19
HAY SILAGE	25	50	50	16	25
GRAIN INDIV FED	14	84	73	*13	85

* 13% CRUDE PROTEIN RECOMMENDED

SUMMARY OF COWS NOW IN HERD

LACT NO	NUMBER COWS	PROJECTED 305-2X-ME MILK	FAT	INDEX	AVERAGE AGE	% IDENTIFIED SIRE	DAM
1ST	6	13533	493	99	2-05	67	67
OTHER	22	13373	515	99	5-09	77	41
ALL	28	13405	511	99	5-02	75	46

COWS MILKING ON SAMPLE DAY

LACT NO	NUMBER COWS	AVG DAYS IN MILK	AVG LBS MILK	AVG PEAK LBS MILK
1ST	5	93	40	43
OTHER	20	141	46	61
ALL	25	132	45	57

CURRENT MASTITIS EVALUATION

LACT NO	NUMBER COWS	PERCENT COWS NEGATIVE	SUSPECT	POSITIVE	V STRONG
1ST	5	20	20	20	40
OTHER	18	22	22	33	22
ALL	23	22	22	30	26

YEARLY SUMMARY

LACT NO	COWS ENTERING HERD NUMBER	%	COWS LEAVING HERD NUMBER	%
1ST	9	29	4	13
OTHER	7	23	14	45
ALL	16	52	18	59

REPRODUCTIVE SUMMARY

	NUMBER COWS	AVG DAYS SINCE CALVING	NUMBER COWS OPEN < 60 DAYS	60-120 DAYS	> 120 DAYS	NUMBER COWS BRED 1 TIME	2-3 TIMES	4+ TIMES	COWS - BREEDING INTERVAL < 18 DAYS	18-24 DAYS	> 24 DAYS	CALVED TO 1ST BRED DAYS	CALVED TO LAST BRED DAYS	MINIMUM CALVING INTERVAL MONTHS
PREGNANT COWS	7	276		6	1	6	1			.	1	74	85	12.0
POSSIBLY PREGNANT	11	147	1	7	3	7	2	2		1	3	72	119	13.1
OPEN COWS	10	44	8		1	1			.					

CONCEPTION RATE = 78%   HEAT DETECTION INDEX = 50%

AVERAGE AI SIRE PREDICTED DIFFERENCE

SIRE	NUMBER	MILK	DOLLAR
SERVICE	16	843	94
1ST LACT	4	729	91
OTHER	15	220	12

COWS DRY BEFORE CALVING

NO COWS	AVG DAYS DRY	< 40 DAYS	40-70 DAYS	> 70 DAYS
18	60	4	9	5

BREED OF HERD	AVERAGE BODY WT
HOL	1230

DAILY HERD TOTALS

MILK SOLD	DHI MILK	GRAIN	INCOME OVER FEED COST
828	1119	392	92

SAMPLE DAY PRODUCTION: SAMPLE DATE	TOTAL COWS	% IN MILK	MILKING COWS ONLY: AVG DIM	MILK	%	DHI ROLLING HERD AVG ENTIRE HERD: MILK	%	FAT
1-05-79	28	89	132	45	3.9	14059	3.8	532
12-02-78	28	75	148	35	3.7	14098	3.8	532
11-07-78	29	72	158	34	3.9	14270	3.8	540
10-12-78	28	86	163	38	3.6	14317	3.8	542
9-16-78	26	96	182	41	3.7	14214	3.8	540
7-22-78	33	85	167	43	3.5	13958	3.8	535
6-13-78	33	97	161	48	3.9	13797	3.8	527
5-17-78	33	88	148	51	3.9	13601	3.8	516
4-18-78	32	84	123	51	3.9	13505	3.8	509
3-21-78	33	79	133	53	3.8	13409	3.8	503
2-19-78	31	84	128	49	3.8	13368	3.7	500
1-08-78	30	83	168	43	3.9	13639	3.7	509
12-12-77	29	86	167	44	3.9	13793	3.7	514

)UCTION, INCOME AND FEED COST SUMMARY

:rd Averages are given for important production income ·d items. These herd average values include all cows in d, milking and dry.

.E DAY AVG PER COW – this column provides herd · per cow on sample day for evaluation of the current ›f the herd.

ƆLLING HERD AVG – column of herd average infor- on a per cow basis for the 365 day period through the : sample day. Averages for new herds within the past ▪ for the period of enrollment.

:R COWS – herd size on sample day, and average num- cows in herd for past 365 days.

/S IN MILK – less than 86% in the yearly average indi- xcessive dry days and suggests the need for corrective

LBS, % FAT, FAT LBS – DHI herd average production luation of management and herd quality.

AMOUNTS (LBS): DRY FORAGE, HAY SILAGE, SILAGE, OTHER FORAGE, GRAIN – sample day feed ts are reported as consumed with no adjustments for atter content (as fed). See feed information in Manage- Section. Rolling yearly averages are reported on 100% itter basis to adjust for variations in moisture.

GE DM PER CWT BW – forage dry matter consumed) lbs of average herd body weight. Values above 2.5 are id values below 1.5 are low indicating possible reporting or unusual forage program.

GY AND PROTEIN INDEXES – percent of herd av- requirements for energy and protein provided by feed reported. Protein and energy requirements are based ds for milk production, fat percent, body weight, gesta- nd growth of young cows. Indexes between 100-110% rmal. A low index indicates underfeeding, or under- ng whereas a high index suggests overfeeding or over- ng.

PER LB GRAIN DM – pounds of milk produced for ound of grain (dry matter) consumed. Normal range is 3.5 lbs milk per pound of grain dry matter. Lower values t inefficient use of grain.

'E OF PRODUCT – average gross value of milk pro- per cow based on milk price and milk produced.

L FEED COST – average per cow cost of feed including s, grain, and protein.

ME OVER FEED COST – difference between value of ct and total feed cost. Fixed costs of production, such es, depreciation, veterinary expenses, etc. must be sub- d from income over feed cost to obtain labor income.

COST PER CWT MILK – the cost of feed to produce s (cwt) of milk is an economic efficiency measure.

PRICE PER CWT – the milk price reported, adjusted average fat percent of the herd.

SAMPLE DAY FEED

Up to 5 lines of information related to kinds of feed and method of feeding may be indicated. AVG LBS CONSUMED is reported on an "as fed" basis with the dry matter indicated in the next column (PCT DM). NET ENERGY and CRUDE PROTEIN values are reported on a 100% dry matter basis for forages, 88% (air dry) basis for grains. Feed costs (COST $/TON) are listed on an as fed basis based on what was reported. If prices were not reported current prices of shelled corn and soybean meal are used to calculate feed costs.

SUMMARY OF COWS NOW IN HERD

An evaluation of cows in the herd on sample day comparing first lactation cows to other cows and all cows in herd.

NUMBER COWS – herds normally have 20-35% of their herd in first lactation. A low percent first lactation cows limits cow culling opportunity.

PROJECTED 305-2X-ME (milk and fat) and INDEX – comparison of first and other lactation groups of cows in the herd. First lactation cows should be equal or superior to other cows when properly raised and sired by superior bulls. Low first lactation averages may indicate needed improvements in raising herd replacements or selection of sires.

AVERAGE AGE – first lactation cows calving before 2 yr 2 mo are usually most profitable if properly raised. The average age of other cows is influenced by how long cows stay in the herd.

% IDENTIFIED SIRE AND DAM – complete identification is essential for genetic evaluations and good management. A low percent identified by sire or dam indicates the need for an improved identification system.

COWS MILKING ON SAMPLE DAY

Evaluations include only cows milking on sample day for first and other lactation animals. AVERAGE DAYS IN MILK (stage of lactation), AVERAGE POUNDS OF MILK and AVERAGE PEAK POUNDS OF MILK provide an analysis of current average performance relative to the average peak milk production for cows now in milk in herd. Peak milk lbs is the highest sample day milk weight for current lactation. First lactation "peak milk lbs" should average at least 70% of the peak milk lbs obtained from older cows.

CURRENT MASTITIS EVALUATION

A current herd analysis of first and other lactation animals showing percent incidence of NEGATIVE, MILD and STRONG indications of mastitis. A 15-25% mild mastitis score is considered normal. More than 25% strong indicates a herd mastitis problem. First lactation cows should have a high percent (more than 80) in the negative column.

YEARLY SUMMARY

To evaluate herd turnover, the number of cows entering and leaving the herd is summarized by first and other lactation groups over the past 12 months. The percent is based on number of cows in rolling yearly average.

REPRODUCTIVE SUMMARY

Note: Failure to report all breeding dates each sample day results in unreliable information. Only cows currently in the herd are included in the summary.

Summaries are provided for PREGNANT COWS (90 or more days since last breeding date or cows reported pregnant), POSSIBLY PREGNANT COWS (less than 90 days since last breeding date and not reported pregnant) and OPEN COWS (cows not reported bred and those reported to be open).

NUMBER COWS – summarizes the reproductive status of the cows in the herd on sample day. All cows without breeding dates reported will be treated as open cows.

AVG DAYS SINCE CALVING – the average days between calving and the current sample day.

NUMBER COWS OPEN – the number of cows in herd open less than 60 days (<60), 60-120 days, and more than 120 days (>120). Cows open more than 120 days represent problems which should receive immediate attention if intended to be bred.

NUMBER COWS BRED – the number of cows in the herd bred 1 time, 2-3 times, and 4 or more times. Good first service conception is 60% of cows conceiving on first service with less than 8% requiring four or more services.

CALVED TO FIRST BRED – average days from calving to first breeding shows when first breeding occurs. Reasonable goal is 50-75 days. Longer intervals to first breeding will lengthen calving intervals.

CALVED TO LAST BRED – days from calving date to last reported breeding date. Cows must be pregnant by 80-85 days post-calving to achieve a 12 month calving interval. The difference (days to last breeding minus days to first breeding) is the days in the breeding period lost because of conception or heat detection problems.

BREEDING INTERVAL – cows are summarized by days between breeding indicating the numbers of cows with abnormally short cycles (less than 18 days), normal cycles (18-24 days) and long cycles (more than 24 days). More than 15% of the cows having long cycles usually indicates need for improving heat detection. At least 80% of the cows should be normal. Cows with intervals less than 18 days indicates heat detection or cystic problems.

MINIMUM CALVING INTERVAL MONTHS – the estimated calving interval based on days open to last breeding plus gestation length (282 days). All cows must have conceived on the last reported breeding date to achieve this projected calving interval. A desirable calving interval is 12-13 months.

CONCEPTION RATE - the percent of cows becoming pregnant at any one Breeding.

HEAT DETECTION INDEX - an estimate of the percent of heats observed based on breeding interval.

AVERAGE A.I. SIRE PD

A herd analysis of A.I. sires used in the past and currently. To obtain a complete summary for your herd, report NAAB codes (e.g. 12H345) for cow's sire and service sires.

Summaries are provided for proven A.I. SERVICE sires currently being used in your herd and proven A.I. sires of 1ST LACT and OTHER cows in your herd.

NUMBER - The number of cows on sample day included in this summary.

MILK - The average predicted difference milk of sires of cows or service sires weighted by sire usage.

DOLLAR - The average predicted difference dollar value of sires of cows or service sires weighted by sire usage.

COWS DRY BEFORE CALVING

An evaluation of dry period length providing a count of cows that continued from a previous lactation and were dry. The average days dry and number of cows with short dry periods (<40 days), normal dry periods (40-70 days), and with long dry periods (>70 days) is provided. Avoid dry periods less than 40 and greater than 70 days.

BREED OF HERD

The breed of 75% or more of the cows in the herd.

AVERAGE BODY WT.

The average estimated body weight of cows in the herd. Estimates are based on herd average mature body weight and breed reported adjusted for age and breed of cows.

DAILY HERD TOTALS

MILK SOLD based on last three milk shipments and number of milkings.

DHI MILK is sample day herd total from milk weights reported.

GRAIN total lbs fed herd on sample day.

INCOME OVER FEED COST for herd on sample day based on DHI sample day feed and milk reported.

SAMPLE DAY PRODUCTION AND DHI ROLLING HERD AVG, ENTIRE HERD

Information for the most recent sample day is listed first and in succeeding order by sample dates for the past year. Herd trends can be evaluated relative to herd size and % cows in milk.

In the MILKING COW ONLY section, the AVG DIM indicates the average days in milk (stage of lactation), along with sample day average MILK and percent fat (%). Two comparisons may be meaningful, one with the preceding month, one with the same month one year previous. The average milk production is expected to increase when the average stage of lactation (DIM) drops by 15 days or more; similarly, milk production is expected to decrease when the DIM increases.

DHI ROLLING HERD AVG, ENTIRE HERD indicates the average milk, percent fat, and fat production for the last 365 days, with the yearly period ending on the sample date indicated. Current herd average (top line) trends are best compared with the same data approximately one year earlier (bottom line).

Abbreviations

AC	-	Alternating Current
CPA	-	Cooperative Power Association
DHIA	-	Dairy Herd Improvement Association
DC	-	Direct Current
DRPC	-	Dairy Records Processing Center
FCM	-	Fat Corrected Milk
KV	-	Kilovolts
UPA	-	United Power Association
305 2xME	-	305 Day Mature Equivalent Records

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