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AN OBSERVATIONAL STUDY APPROACH TO INVESTIGATING ISSUES RELATED TO MILK PROTEIN PRODUCTION IN DAIRY COWS

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Un protocole d'observation à plusieurs niveaux a été utilisé pour étudier la production de protéines chez la vache laitière. A l'échelle de l'industrie (province de l'Ontario), des données historiques sur la production ont été utilisées pour examiner les tendances dans la production de protéines et les réponses de l'industrie aux changements dans la politique de quotas. Deux questionnaires sur la conduite d'élevage ont été utilisés pour étudier les associations entre la démographie du troupeau, la conduite d'élevage, et les facteurs nutritionnels d'une part, et la production moyenne de protéines dans l'élevage d'autre part. Des informations à l'échelle de la vache ont été collectées dans 83 élevages pendant deux ans. Les données de production ont été obtenues sur support informatique à partir des organisations provinciales DHI. L'occurrence des maladies était notée pas les éleveurs. Ces données ont été utilisées pour analyser les associations entre les facteurs individuels et la production de protéines du lait, et pour étudier les relations entre haut niveau de production de protéines d'une part, et santé de la vache, performances de reproduction et survie d'autre part.

INTRODUCTION

In Canada, over the past several decades, there have been changes in consumer preferences for dairy products. Consumption of products high in fat, such as whole milk and butter, have decreased, with an increase in milk protein containing products such as cheese. In Canada, the dairy industry is supply-managed, with quota allocation and pricing schemes designed to match the supply of dairy production with consumer demand. In response, the dairy industry in the province of Ontario recently adopted a multiple component pricing system with an increasing financial incentive for protein production. As a result, dairy producers are interested in how to increase yields of milk protein, as well as identifying any potential changes in cow performance related to increased protein production. Thus, an observational study was designed to investigate factors relating to protein production at the provincial, herd, and individual cow level (Sargeant, 1996). The observational study design approach was used to incorporate the real-world complexity of production issues. The multi-level approach allowed different aspects of protein production to be addressed. The aim of this paper is to describe some of the data collection and analytical issues used in this study.

PROVINCIAL LEVEL

The objectives of the study at the provincial level were to describe the trends in milk component production over time, and to identify any changes in farm average protein and fat production associated with changes in the allocation and/or payment schemes for milk. As a supply-managed system, all of the milk produced in Ontario is purchased by the Dairy Farmers of Ontario (DFO), who subsequently distribute the raw product to processors. Thus, monthly data on the amount and composition of milk shipped from all farms in the province is kept by the DFO, with archival records extending back to 1985.

Initially, the farm level data were summarized to provide monthly production averages for the province. Graphs of these data were then used to visualize the trends in milk and milk component production between 1985 and 1994. Milk, protein, and fat yields increased over the ten year period, and there was a pronounced seasonality to the data. Fat percent also increased over the same period, with a small, but statistically significant increase in protein percent. Time series analysis was used to investigate the industry response to changes in the allocation and/or payment schemes for milk. Hierarchically coded dummy variables, corresponding to several changes in policy, were included in an autoregression model which controlled for the seasonality of the data and the linear time trend. This allowed production after the introduction of a policy change to be compared to previous production, controlling for the baseline increases in production seen over time. There were no specific responses to changes in quota policy, including the introduction of a multiple component pricing system. The type of production response which could be detected with the analysis used would be changes that could be realized over a short time period, such as nutritional changes. However, the analysis suggested that changes to milk pricing have not yet had the desired effect of changing the relative production of milk components.

State transition models were used to assess whether farms with high or low relative protein production in a given year maintained their relative performance in the subsequent year. Relative farm mean protein percent over time was not entirely random; herds tended to stay in their respective protein percent category in the next year, suggesting that there are farm level factors associated with protein production.

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HERD LEVEL

The objective at the herd level was to identify associations between herd demographic, management, and nutritional factors, and protein production. Herd level factors were investigated using two farm management questionnaires; a general management questionnaire administered to a random sample of 900 dairy producers, and a more intensive questionnaire administered by interviewer to 83 dairy producers. In order to facilitate delivery and collection and potentially increase response rates for the general management questionnaire, this questionnaire was distributed and collected by Ontario Dairy Herd Improvement customer service representatives during their regular milk recording visits to the farms. The response rates were 69% for the DHI customer service representatives and 81% for dairy producers.

Protein production was defined as herd average protein yield per cow per day. While herd average protein percent has been used as an outcome in previous studies, protein yield, as the basis of payment systems, was a more germane outcome under the Canadian marketing system. The analyses included linear regression modeling and principal component analysis.

The initial purpose of using two questionnaires was to first identify general areas of potential importance with a shorter survey, and to follow-up these observations with an intensive questionnaire. However, due to the low variability in herd mean protein yield, the high correlation between milk and protein yields, and the low prevalence of some management techniques on participating farms, the small sample size used for the intensive management questionnaire meant that this questionnaire had low power to detect significant differences in herd mean protein yield.

The ability to identify associations between herd level factors and protein yield in both questionnaires was complicated by the high correlation between milk and protein yield (R=0.96). While a number of management factors were associated with increased protein production in unconditional analysis, the majority of these associations became insignificant after controlling for herd average milk yield. This may suggest that herd average protein yield can most effectively be increased by increasing herd average milk yield, and that specifically manipulating protein yield at the herd level may be difficult. However, given the wide range in nutritional programs, and the difficulties in identifying specific dietary ingredients using a questionnaire format, the effect of specific nutritional practices was not examined.

INDIVIDUAL COW LEVEL

The objectives at the individual cow level were two-fold: to investigate associations between individual cow factors and protein production, and to identify any associations between protein production and cow health, reproductive performance, and survivorship. Individual cow protein production was defined by 305 day lactation protein yields (incorporating both environmental and genetic influences) and by estimated breeding values (representing genetic potential).

The study group consisted of 83 dairy herds located in the provinces of Ontario (n=75), Alberta (n=5), and Nova Scotia (n=3). The herds were identified by veterinarians participating in the Dairy Health Management Certificate Program, a continuing education program at the Ontario Veterinary College (Leslie, 1992). Data were collected at the individual cow level over a two year period. Production and somatic cell count data were obtained electronically from the provincial DHI organizations. Health data were collected with the assistance of the DHI organizations. The DHI organizations normally provide producers with a 'herd event record', which is a chart designed to be attached to the barn wall, and used to record cow information such as calving dates, breeding dates, etc. With the co-operation of DHI, we modified that record-keeping system to include a disease event section. Whenever a producer or a veterinarian treated a cow, the date and cow identification were entered, and the appropriate disease was checked off from a list of common cow diseases. This information was recorded by the DHI customer service representatives during regular scheduled visits to the farm for milk recording. This co-operative effort resulted in considerable savings in time and resources.

The farms were visited on a regular basis by a field technician, as part of a concurrent vaccine trial (Scott et al., 1996). Cow data were collected at that time, which allowed partial validation of the electronic data. In the electronic data set, calving, dry-off, and culling dates occupied a single field. Thus, if a cow experienced more than one of these events during a test interval (approximately one month), then only the last event, chronologically, was retained. Validation with paper records revealed that calving dates were overwritten by culling dates for 3.3% of calvings and dry-off dates were overwritten by calving or culling dates for 1.8% of dry dates. During the initial period of data validation, the recorded disposal reasons for culled animals differed between the electronic and the paper records 26.4% of the time. Thus, it is important that data validation be performed when previously existing data sources are utilized.

Causality is difficult to prove in an observational study design. One of the essential components of causality is the temporal relationship between factors. Thus, when data are collected on individual animals over time, it is essential to ensure that factors postulated to 'cause' differences in production have a logical chronological relationship to the production being measured. For instance, when assessing whether cows with high protein production were more or less likely to experience disease, protein yield in the previous lactation was used to define production. This reduced the likelihood that associations arising from the disease 'causing' the production would be identified.

Disease, reproductive, and culling outcomes were analyzed separately. Breed, parity, season of calving, and level of milk production were controlled as potentially confounding variables. The herd effect was controlled as a random effect. The reproductive outcomes of days open and days to first breeding were continuously distributed, thus, a linear regression approach with a random effect control of herd was used. When investigating the relationship between disease as an outcome and protein production, the analyses used logistic regression, with a farm-specific, random effect control for herd (Schall's algorithm) (Schall, 1991). Culling data were analyzed

using a GEE model with a Poisson error structure, offset by the log of the survival time and with a population averaged random effect control of herd (Segal and Neuhaus, 1993).
There was a high correlation between protein and milk production, and between the genetic potential for milk and protein production, at the individual cow level. After controlling for herd and the confounding variables, there were no significant associations between protein production and days open or days to first service. Several diseases had small, but statistically significant, associations with protein yield and / or genetic potential for protein yield in unconditional associations. However, after controlling for milk production, the majority of these associations were no longer significant. These results suggest that any relationships which exist between disease and production are related to production in general, rather than protein production specifically. High protein yield and estimated breeding values for protein yield tended to have a sparing effect on the risk of culling.

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