PREDICTION OF LIFETIME MILK REVENUE FROM FIRST LACTATION PHENOTYPE

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SUMMARY
Multiple regression analysis was used to develop prediction equations for lifetime milk revenue from Holstein cattle in the Canadian maritime region. First lactation 305 day protein yield was a notable predictor of lifetime milk revenue in three of the four prediction equations with different definitions of value of lifetime product. Discrepancies were detected between the ideal values established by the breed association and those observed in this study for two conformation traits (foot angle and udder texture). Value of lifetime product and discounted value of lifetime product were easier to calculate and present and thus more desirable as measures of lifetime milk revenue.
Keywords: Dairy, cattle, prediction, revenue

INTRODUCTION
Improving lifetime profitability is practical through indirect selection on correlated traits. However, few studies have attempted to predict lifetime profitability from the first lactation phenotype of a dairy animal. Lifetime milk revenue was used as a measure of lifetime profitability, because it could be calculated directly from production records; Norman *et al.* (1981) found that lifetime milk revenue was significantly correlated with lifetime profitability (r=0.69). Correlations between estimates of financial aspects of the dairy operation such as carcass value, value of the calf, total expenses, and lifetime profitability were found to be small and insignificant (Balaine *et al.* 1981), and not considered here.

Kulak (1994) singled out first lactation milk revenue, udder depth, length from shoulder to hook bones, and rump length as significant predictors of lifetime profitability. However, the majority of production and conformation traits used in that study are not presently measured in Canadian commercial herds. Therefore, the objective of this study was to develop prediction equations for lifetime profitability through the use of lifetime milk revenue, with data from the Canadian milk recording and classification programs.

MATERIALS AND METHODS
The data came from the Maritime provinces of Canada consisting of New Brunswick, Nova Scotia, and Prince Edward Island. Edited data was comprised of 8689 Holstein cows that had 60 months of opportunity for production in a continuously tested herd after first calving, remained in the same herd for their entire productive life, calved for the first time between 18 and 36 months of age, and had at least 5 contemporaries in the same herd and year of first calving.

The four measures of lifetime profitability were value of lifetime product (VLP), discounted value of lifetime product (DVLP), value of lifetime product adjusted for the opportunity cost of postponed

Table 1. Prices for milk and milk components in the Maritime provinces in Canadian dollars per kilogram[A]

	Fat	Protein	Other Solids
Nova Scotia	4.9450	8.5786	1.2577
New Brunswick	4.9958	8.2290	1.2583[B]
Prince Edward Island	5.2459	6.2258	2.5289

[A]December 1996
[B]Lactose

replacement (VLPOC), and discounted value of lifetime product adjusted for the opportunity cost of postponed replacement (DVLPOC), applying a discounting rate of 5%. Value of product was calculated with the pricing formula corresponding to the province in which the cow lived (Table 1). Milk carrier price was equal to the unit price for other solids multiplied by percent composition, assuming the percentage of other solids and lactose was 5.67 and 4.81, respectively (Barbano *et al.* 1992). Variance of VLP, DVLP, and days of productive life within herd and year of first calving were calculated in order to estimate the opportunity cost of postponed replacement (OC). OC was estimated with a procedure similar to de Haan *et al.* (1992).

The regression model used for the analysis was as follows:

$$\text{Profit}_{ij} = \mu + HYF_j + AFC_i + \Sigma b_k x_{ik} + e_{ij}$$

where Profit_{ij} is the measure of lifetime profitability of the i-th cow in the j-th herd-year of first calving; μ is the overall mean of the population; HYF_j is the effect of the j-th herd-year of first calving on the measure of lifetime profitability; AFC_i is the age of first calving of the i-th cow (in days); b_k is the partial linear or quadratic regression coefficient for the effect of the k-th independent variable on lifetime profit; x_{ik} is the k-th independent variable from the i-th cow, and e_{ij} is the residual error of the observation on the i-th cow in the j-th herd-year of first calving.

Herd-year of first calving was a fixed effect. Age at first calving was a concomitant variable. The independent variables consisted of descriptive conformation traits as well as first lactation 305 day milk, fat, and protein yields. A stepwise regression procedure was used to identify predictors of lifetime profitability for each of the dependent variables. A high level of significance (α<5%) for inclusion and retention in the model was used in order to develop a minimalistic prediction equation that explained a large proportion of the variation in lifetime profitability.

RESULTS AND DISCUSSIONS

The prediction equations explained 31 to 32 % of the total variation in the measures of lifetime milk revenue. This was slightly lower then the R^2 values obtained by Kulak (1994). Correlations between DVLP and udder traits were similar to those observed by Norman *et al.* (1996), with the exception of udder depth and median suspensory ligament. Table 2 summarizes the partial regression coefficients for traits in the prediction equation for VLP. The conformation traits seem to be more

Table 2. Partial and standardized regression coefficients of VLP on prediction traits, R^2=0.31.

Trait	Partial Regression Coefficient	Standard Error	P-value	Standardized Regression Coefficient
Age at first calving	-10.74	1.10	0.0001	-0.115
305 day milk yield	1.86	0.21	0.0001	0.276
Fore udder attachment	335.82	77.00	0.0001	0.055
Bone quality	269.28	60.60	0.0001	0.049
305 day protein yield - linear	81.82	19.19	0.0001	0.394
305 day protein yield - quadratic	-0.13	0.04	0.0005	-0.287
Udder texture - linear	1248.06	392.93	0.0015	0.206
Udder texture - quadratic	-87.18	34.14	0.0107	-0.166
Foot angle	277.70	65.05	0.0001	0.047
Rear udder attachment height	404.73	81.69	0.0001	0.062
305 day fat yield	10.50	3.76	0.0053	0.059
Loin strength	149.90	55.65	0.0071	0.029
Median suspensory ligament	154.54	74.64	0.0384	0.026

important than the production traits, based on the partial regression coefficients. This could be attributed to the scale of the traits. All of the conformation traits were rated by classifiers using a nine point scale, whereas production traits were measured on a kilogram basis and therefore had a much larger range. The standardized regression coefficients show the most important trait in the model was 305 day protein yield, and udder texture was the most important conformation trait.

Optimum values for conformation traits in the VLP model did coincide with the ideals designated by Holstein Canada except for udder texture and foot angle. The desired rating for udder texture is 9 according to the breed association, but the prediction equation for VLP indicates that it should be 7, and the exact opposite occurs for foot angle. This difference between ideal conformation ratings was also observed in the model for DVLP. However, the discrepancies could be the result of few observations in the upper tail of the distribution of the traits.

In general, the VLP and DVLP models retained the same traits in the model. However, the partial regression coefficients were smaller for the DVLP model, which was a result of discounting milk revenues. Both equations included linear and quadratic effects of 305 day protein yield, but there was a difference in the optimal yield (292 versus 320 kg for VLP and DVLP, respectively).

The traits included in the models for VLPOC and DVLPOC were substantially different from those for VLP and DVLP. The prediction equation for DVLPOC included linear effects of age at first calving, 305 day protein yield, 305 day fat yield, fore udder attachment, 305 day milk yield, stature, and pin width. Quadratic effects of 305 day milk yield and stature were also included. The VLPOC prediction equation was notably different, because it consisted of linear effects of age at first calving, 305 day protein and fat yields, pin width, and the quadratic effect of 305 day protein yield.

The shape of the curve described by the linear and quadratic effects for 305 day protein yield from the VLPOC equation started above the x-axis, approached a minimum value that was positive, and then began to slope upwards and to the right. The later part of the curve suggests lifetime milk revenue would increase continually as first lactation protein yield increases. Ever increasing lifetime milk revenue is in conflict with production economic theory, which maintains that profits (lifetime milk revenue) should increase at a decreasing rate as input (kilograms of first lactation protein yield) increases. It also conflicts with the results of Shanks *et al.* (1978), where an increased rate of health problems in higher producing animals was observed. The curve for 305 day milk yield in the DVLPOC equation was similar to that described by the relationship between lifetime milk revenue and 305 day protein yield in the prediction equation for VLPOC, except it started below the x-axis, and positive values for lifetime milk revenue were not observed until 15415 kg of first lactation milk yield. No peculiar trends were observed in the prediction equations for VLP and DVLP.

Despite minute differences in R^2 values, VLP and DVLP would be more desirable than VLPOC and DVLPOC for predicting lifetime milk revenue, because of the ease of computation as variances for days of productive life, VLP, and DVLP are not needed. Furthermore, results of analyses using VLP and DVLP as measures of lifetime milk revenue can be presented more easily to producers, without an in-depth explanation of the processes and calculations utilized.

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