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# THE EFFECT OF DISEASES ON CULLING IN NEW YORK STATE HOLSTEIN DAIRY COWS

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*L'effet de 7 troubles de santé sur la réforme a été étudié à partir de 7523 vaches Holstein de l'Etat de New-York, ayant vêlé en 1994 et suivies jusque fin septembre 1995. Une analyse de survie utilisant le modèle de risques proportionnels de Cox a été réalisée en incorporant les maladies comme covariables dépendantes du temps (CDT). Différents intervalles représentant des stades de lactation (SDL) ont été considérés pour l'effet des maladies. Quatre modèles ont été ajustés, testant les effets de la production laitière (PL), du statut de gestation (SG) et des maladies. Les covariables incluaient la parité, la saison de vêlage et les CDT associées aux maladies, à la PL actuelle et au SG. Les données étaient stratifiées intra-troupeau. Les 7 maladies considérées étaient (avec leur incidence / lactation) : les fièvres vitulaires (0,9%), les rétentions placentaires (RP) (9,5%), les déplacements de caillette (DC) (5,3%), les cétoses (5.0%), les métrites (4,2%), les kystes ovariens (10,6%) et les mammites (14,5%). Les vaches ayant une PL manquante avaient un risque très élevé alors que celles ayant une bonne PL étaient protégées. Une fois gestantes, le risque de réforme des vaches chutait fortement. Les RP et les métrites n'avaient aucun effet sur la réforme. Les mammites étaient un facteur de risque important pendant toute la lactation et pour tous les modèles. Les fièvres vitulaires, les DC, les cétoses et les kystes ovariens avaient également un effet significatif, à différents stades de lactation. Ces effets décroissaient lorsque la PL et le SG étaient inclus comme covariables mais restaient importants. Ces résultats indiquent que les troubles de santé jouent un rôle important à la fois sur la décision de réformer et sur la date de cette réforme.*

## INTRODUCTION

Culling is a complex issue; many factors are involved. Dairy cows are culled for involuntary (death, disease, infertility) or voluntary (low yield) reasons. Both biology and management affect culling decision making. In his decision, the farmer considers 3 major reasons: 1) illness, 2) low yield, and 3) reproductive failure. The main interest of this paper was to study the effect of several diseases on culling. They may act through milk yield (MY), or conception rate. To what extent diseases act on culling through lower MY or infertillity is unclear. Diseases have different effects, depending on when they occur, and when the effect on culling is seen. Time-dependent covariates (TDCs), whose values change with when they are observed, address this issue. Only a few recent studies (1, 3) using survival analysis have regarded the time dependence of some covariates; before, they could not be handled by available numerical techniques. We described the methodological aspects of estimating the mastitis effect on culling, regarding mastitis as a TDC (3). An interaction between the times of mastitis occurrence and actual culling was important. Here, we will study the effect of 7 diseases on culling, adjusting for MY and conception status (CS). Their interaction with SOL will be accounted for.

## MATERIALS AND METHODS

The data consisted of 7523 Holstein cows in 14 New York State herds. Cows calved from Jan. 1-Dec. 31, 1994, and were followed until Sept. 30, 1995. Data on calving and culling or censoring dates, parity, previous 305-d MY, current MY at 30, 60, 120, 180, and 240 d, and dates of occurrence, if any, of milk fever, retained placenta, displaced abomasum (DA), ketosis, metritis, ovarian cysts, and mastitis, and of subsequent conception, were available. The outcome was the number of days between calving and culling or censoring. A cow was considered culled if she left the herd for any reason, e.g., death, or sale for meat or dairy. If a cow began a new lactation during the study period, she was censored on her new calving date. A cow was also censored if she was still in the herd on the last day of the study period (Sept. 30, 1995) and had not yet begun a new lactation.

When the disease occurs, and when it induces culling are considered in this study. We decided that this was the proper way to model the effect of mastitis on culling (3). For each ill cow, it was of interest to see the disease effect on culling in subsequent SOLs. TDCs allow each disease effect on culling to differ depending on the period when disease occurred and on the SOL when the effect on culling is seen. Periods and stages for each disease are given in Table I.

Four Cox proportional hazards models were fitted; parity and calving season were in all models. Model 1 contained disease by SOL interactions. Model 2 also included current MY. Model 3 included diseases and CS. Model 4 included diseases, MY, and CS. Disease effects alone (Model 1) were compared with the disease effects adjusted for MY (Model 2), CS (Model 3), and both MY and CS (Model 4). Risk ratios (RR) and 95% confidence intervals (CI) were obtained for the covariates in each model. Models were fitted using a set of FORTRAN programs (2) .

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**Table I**

**Denotation of disease occurrence and their effects on stage of lactation (7523 New York Holstein dairy cows calving in 1994; followed until Sept. 30, 1995). Values are days in lactation.**

| Period of occurrence | Milk fever | Retained placenta | Displaced abomasum | Ketosis | Metritis | Ovarian cysts | Mastitis |
|---|---|---|---|---|---|---|---|
| 1 | as it occurs | as it occurs | as it occurs | as it occurs | as it occurs | 1-120 | 1-60 |
| 2 | ... | ... | ... | ... | ... | >120 | 61-150 |
| 3 | ... | ... | ... | ... | ... | ... | 151-270 |
| 4 | ... | ... | ... | ... | ... | ... | >270 |
| Stage of lactation | | | | | | | |
| I | 1-30 | 1-30 | 1-30 | 1-30 | 1-60 | 1-60 | 1-30 |
| II | 31-240 | 31-240 | 31-60 | 31-120 | 61-240 | 61-240 | 31-60 |
| III | >240 | >240 | 61-120 | 121-180 | >240 | >240 | 61-120 |
| IV | ... | ... | 121-180 | 181-240 | ... | ... | 121-180 |
| V | ... | ... | 181-240 | >240 | ... | ... | 181-240 |
| VI | ... | ... | >240 | ... | ... | ... | >240 |

## RESULTS AND DISCUSSION

The overall rate of culling in the 14 herds was 23.6%. Disease effects on culling are shown in Table II. Retained placenta and metritis had no effect on culling.

**Table II**

**Risk ratios (RR)[1] and 95% confidence intervals (CI's) for factors in final Cox proportional hazards models (see text for details), for culling (7523 New York Holstein dairy cows calving in 1994, followed until Sept. 30, 1995).**

| | Model 1 | | Model 2[1] | | Model 3[2] | | Model 4[3] | |
|---|---|---|---|---|---|---|---|---|
| Covariate | RR | 95% CI | RR | 95% CI | RR | 95% CI | RR | 95% CI |
| Milk fever[4] | | | | | | | | |
| 1, I | 2.1* | 1.1, 3.9 | 2.2* | 1.2, 4.3 | 2.2* | 1.1, 4.1 | 2.3* | 1.2, 4.5 |
| 1, III | 1.6 | 0.8, 3.0 | 1.4 | 0.7, 2.7 | 2.3** | 1.2, 4.5 | 2.1* | 1.1, 4.0 |
| Displaced abomasum[4] | | | | | | | | |
| 1, I | 2.4*** | 1.5, 3.8 | 2.4*** | 1.5, 3.7 | 2.4*** | 1.5, 3.7 | 2.3*** | 1.5, 3.6 |
| Ketosis[4] | | | | | | | | |
| 1, I | 1.9* | 1.2, 3.0 | 1.9** | 1.2, 3.1 | 1.9** | 1.2, 3.0 | 1.9** | 1.2, 3.1 |
| 1, III | 2.0** | 1.2, 3.4 | 1.9* | 1.1, 3.1 | 1.9** | 1.2, 3.2 | 1.7* | 1.0, 2.8 |
| 1, V | 2.0*** | 1.4, 2.7 | 2.1*** | 1.5, 2.9 | 1.5* | 1.1, 2.0 | 1.6** | 1.2, 2.3 |
| Ovarian cysts[4] | | | | | | | | |
| 1, II | 0.9 | 0.6, 1.2 | 1.0 | 0.7, 1.4 | 0.6* | 0.5, 0.9 | 0.7 | 0.5, 1.1 |
| 2, II | 1.0 | 0.6, 1.8 | 1.2 | 0.7, 2.1 | 0.6* | 0.3, 1.0 | 0.6 | 0.4, 1.1 |
| 2, III | 1.4* | 1.1, 1.9 | 1.9*** | 1.4, 2.5 | 0.8 | 0.6, 1.1 | 1.0 | 0.7, 1.3 |
| Mastitis[4] | | | | | | | | |
| 1, I | 1.9*** | 1.3, 2.8 | 1.9*** | 1.3, 2.8 | 1.9*** | 1.3, 2.8 | 1.9*** | 1.3, 2.8 |
| 1, II | 2.5*** | 1.6, 3.9 | 1.6 | 1.0, 2.5 | 2.5*** | 1.6, 3.9 | 1.6 | 1.0, 2.5 |
| 1, III | 4.0*** | 2.7, 5.7 | 2.7*** | 1.8, 3.9 | 3.7*** | 2.6, 5.4 | 2.5*** | 1.7, 3.6 |
| 2, III | 7.3*** | 4.0, 13.3 | 6.8*** | 3.7, 12.6 | 6.6*** | 3.6, 11.9 | 6.5*** | 3.5, 11.9 |
| 1, IV | 3.0*** | 2.0, 4.3 | 2.4*** | 1.6, 3.4 | 2.8*** | 1.9, 4.1 | 2.2*** | 1.5, 3.2 |
| 2, IV | 3.9*** | 2.5, 6.2 | 3.2*** | 2.0, 5.1 | 3.6*** | 2.3, 5.6 | 3.0*** | 1.9, 4.8 |
| 1, V | 2.2*** | 1.4, 3.3 | 2.0*** | 1.3, 3.0 | 1.9** | 1.3, 2.8 | 1.7* | 1.1, 2.6 |
| 2, V | 2.2** | 1.3, 3.9 | 1.8* | 1.0, 3.1 | 2.1** | 1.2, 3.7 | 2.0* | 1.1, 3.4 |
| 3, V | 4.9*** | 3.0, 8.0 | 4.4*** | 2.7, 7.3 | 4.0*** | 2.4, 6.6 | 3.6*** | 2.2, 6.0 |
| 3, VI | 1.5* | 1.1, 2.2 | 1.4 | 1.0, 2.0 | 1.3 | 0.9, 1.9 | 1.2 | 0.8, 1.7 |
| 4, VI | 2.7*** | 1.5, 4.6 | 2.7*** | 1.6, 4.8 | 2.6*** | 1.5, 4.6 | 2.7*** | 1.5, 4.9 |

[1]Model 2 also contains parity and current milk yield.
[2]Model 3 also contains parity and conception status.
[3]Model 4 also contains parity, current milk yield, and conception status.
[4]Effect of a disease in a stage of lactation (see Table 1 for period in which disease occurred and stage of lactation when culling hazard was observed) denoted as follows: (i, j) = effect of disease occurring in period i on culling observed in stage of lactation j. All effects are to be compared with the baseline condition of no disease; only significant risk ratios in a time period are shown.
*P<0.05. **P<0.01. ***P<0.001.

Milk fever affected culling in the 1st SOL. After 240 d, the estimate for milk fever rose, in Models 3 and 4. The milk fever effect in Models 3 and 4 was higher than in Model 1 afer 240 d; it may be confounded by CS in Model 1. The adjusted RR (Models 3 and 4) suggests that milk fever increases culling in the 3rd SOL.
DA affected culling only in the 1st SOL. Culling for DA may be independent of culling for MY and CS.

Ketotic cows were more likely to be culled soon after diagnosis; ketosis also affected culling later in lactation. The ketosis effects in each SOL were fairly consistent, even when correcting for MY and CS. An exception was after 240 d, in Models 3 and 4. Ketosis may delay conception; breeding of the ketotic cow is delayed or fertility decreases. When CS was not considered (Models 1 and 2), cows with ovarian cysts after 120 d were more likely to be culled after 240 d. When adjusting for CS, and milk yield (Models 3 and 4), ovarian cysts were not a risk factor for culling. When MY was corrected for (Model 2), the RRs for ovarian cysts were a bit higher than in Model 1.

Mastitis had much influence on culling. For cows with mastitis in the 1st period, the effect on culling in the 1st SOL was constant across models. The mastitis effect was still large but not as important when MY was accounted for (Models 2 and 4). Adding CS (Models 3 and 4) generally caused the mastitis estimate to drop.

By using TDCs, disease effects on culling risk can be estimated over time. One overall measure of the effect of disease on culling is insufficient. Previous work (1, 3) has confirmed the importance of TDCs in survival analysis, so that one can account for a covariate's effect at different times.

## CONCLUSIONS

The results suggest that diseases are important factors in culling. Effects varied with SOL. Including CS changed the RRs somewhat, particularly those of ovarian cysts and milk fever and ketosis in late lactation. The mastitis effect on culling was less when including current MY and CS. This suggests that MY, CS, and ovarian cysts and mastitis (and other diseases) interrelate in their effect on culling. Farmers consider all of these factors in culling decisions.

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