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Risk factors associated with milk fever occurrence in grazing dairy cattle

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ABSTRACT

The aim of this study was to determine risk factors associated with milk fever (MF) occurrence in Costa Rican grazing dairy cattle. A total of 69,870 cows from 126 dairy herds were included in the study. Data were collected in the Veterinary Automated Management and Production Control Program software by the Population Medicine Research Program of the Veterinary Medicine School, National University of Costa Rica, from 1985 to 2014. To determine the risk factors for MF, 2 logistic regression mixed models were evaluated. The first model used breed, month of calving, ecological life zone, herd nested within ecological life zone, and parity as fixed effects. The second model excluded first-lactation animals and cows without production information, had the same fixed effects of the first model, and added previous MF case, previous lactation length, previous dry period length, previous corrected 305-d milk yield, and calving interval length as fixed effects. Both models used animal and year as random effects. Of the 235,971 recorded lactations, 4,312 (1.83%) reported MF event. The significantly associated risk factors for MF occurrence, ranked by their highest odds ratio (OR), were parity (OR = 52.59), previous dry period length (OR = 4.21), ecological life zone (OR = 3.20), breed (OR = 3.04), previous corrected 305-d milk yield (OR = 2.39), previous MF case (OR = 2.35), and month of calving (OR = 1.36). The findings of this study are the first data reported using an epidemiological approach to study risk factors for MF in Costa Rican dairy cattle. Some of these results might be used to improve preventive management practices at the farms to reduce the incidence of this metabolic disease in grazing dairy herds.
Key words: milk fever, risk factor, dairy cattle, grazing cow

INTRODUCTION

The transition period in dairy cattle involves important physiological changes, which increase the risk of metabolic imbalances such as clinical hypocalcemia, also known as milk fever (**MF**; Goff et al., 1987; Goff and Horst, 1997). Milk fever is one of the metabolic diseases that have major negative implications on the profitability of dairy production systems in the United States; the cost per case was estimated at $334 (Guard, 1996). In the United Kingdom, the cost of a MF case was valued at £220 ($343 at a conversion rate of £1.56/US$1.00; Kossaibati and Esslemont, 1996).

The incidence of MF has been reported to be 5 to 7% of the cows housed in confinement (Goff, 2008), which is similar to that reported by Roche (2003), who reported the incidence of MF in grazing systems was 5%. A meta-analysis of 135 controlled studies indicated incidences of this disease range from 0 to 83% (Lean et al., 2006), a range that reveals great potential to influence the incidence of this disease if one understands the factors that are associated with development of MF. Among the risk factors that have been associated with MF are age (the risk increases with increasing age), prepartum diet (high DCAD increases the risk), breed (increased risk for Jersey and Guernsey breeds), milk production (susceptibility increases with herd production), presence of other diseases (increase the likelihood of the imbalance), and background of previous cases (increased risk in animals that have suffered the condition previously; Erb and Gröhn, 1988; Oetzel, 1991; Enevoldsen, 1993).

In Costa Rica, herd-level data collection has been included in the VAMPP (Veterinary Automated Management and Production Control Program) software (Noordhuizen and Buurman, 1984), which has been available to dairy production systems since the mid-1980s. Owners, managers, technicians, professionals, and researchers are among the contributors who collected and entered data for the analysis. The VAMPP database contains currently more than 4,000 registered cases of MF.

Costa Rican grazing dairy farms have a combination of singular characteristics (herd size, breed crosses,

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pastures, ecological life zones, robust data frame) that make it interesting to analyze, because some of those features could change the risk factors associated with MF occurrence; therefore, similarities or differences may exist on factors affecting the incidence of this disease compared with other dairy grazing systems of countries, such as New Zealand or Australia, and with countries with confinement farms, such as the United States or Canada.

The epidemiological determination of the main risk factors associated with MF and their relative contribution to the development of this disease in Costa Rica have not been previously reported. The information generated by this type of analysis can lead farms to implement management practices that will reduce the incidence of this disease.

MATERIALS AND METHODS

Study Design

A longitudinal observational study design was used to analyze the productive and reproductive data collected in the VAMPP national database between 1985 and 2014. The study population consisted of 69,870 cows from 126 herds, with a total of 235,971 registered calving.

Only those herds that reported at least 5 cases of MF between 1985 and 2014 were included in the study. This procedure was performed to filter and reduce the potential effect of underreporting.

An MF case was any cow entered into the VAMPP national database by the herd managers. It is assumed that a reasonably accurate diagnosis of MF was made by herd managers based on symptomology, such as recumbency, time of development of recumbency relative to calving, and response of the cow to treatment with intravenous calcium.

Statistical Analysis

The statistical analysis of factors associated with the occurrence of MF was performed using logistic regression (Kleinbaum and Klein, 2010) by generalized linear mixed models. DeGaris and Lean (2008) argued that the models with random effects are better than fixed effects models, as the latter are vulnerable to overdispersion associated with the cluster effect.

In the analyzed data, a single cow could have several cases of MF during its life; thus, in multiparous cows there may be a correlation in the response associated with the animal. Because of the long period of study, year was included as a random effect in the statistical models. Generalized linear mixed models are a highly flexible modeling strategy that allows not only the inclusion of random effects, but also the specifying of different residual correlation structures (SAS Institute Inc., 2010).

In our study, 2 statistical models were proposed, one referred to as the base model and the other called the full model [eq. 1]. In the base model, risk factors not related to the previous lactation were considered, allowing the inclusion of first-calving cows in the analysis. In the full model, factors related to previous lactation [β_6–β_{10}, eq. 1] were added, so the first-calving females were excluded from this model.

The full model is described as

$$\text{Logit P}(\text{F}_{\text{ijklmnopqrst}} = 1|\text{X}) = (\beta_0 + \text{v}_{\text{oi}}) + \beta_1\text{R}_\text{j} + \beta_2\text{M}_\text{k} + \beta_3\text{Z}_\text{l} + \beta_4\text{H(Z)}_\text{m} + \beta_5\text{N}_\text{n} + \beta_6\text{C}_\text{o} + \beta_7\text{L}_{\text{p}+}\ \beta_8\text{S}_\text{q} + \beta_9\text{P}_\text{r} + \beta_{10}\text{I}_\text{s} + \text{y}_{\text{ot}} + \varepsilon_{\text{ijklmnopqrst}}, \quad [1]$$

where $\text{Logit P}(\text{F}_{\text{ijklmnopqrst}} = 1|\text{X})$ = probability that the ith cow to suffer milk fever belonging to the jth breed, calved at the kth month in the lth ecological life zone, belongs to the mth herd nested within ecological life zone, has nth parity number, oth previous case background of MF, pth previous lactation length, qth previous dry period length, rth previous 305-d corrected milk yield, sth length of calving interval, and calved in the tth year; $(\beta_0 + \text{v}_{\text{oi}})$ = intercept animal-specific for the ith cow; $\beta_1\text{R}_\text{j}$ = fixed effect for the jth breed (Jersey, Holstein × Jersey crosses, Holstein, Holstein × Brown Swiss, Brown Swiss, *Bos taurus* × *Bos indicus*, Guernsey, others); $\beta_2\text{M}_\text{k}$ = fixed effect for the kth month of calving (January to December); $\beta_3\text{Z}_\text{l}$ = fixed effect for the lth ecological life zone, as described by Holdridge (1987), specifically montane wet forest, lower montane rain forest, premontane wet forest, lower montane moist forest, premontane moist forest, lower montane wet forest, and tropical wet forest; $\beta_4\text{H(Z)}_\text{m}$ = fixed effect for the mth herd nested within ecological life zone; $\beta_5\text{N}_\text{n}$ = fixed effect for the nth parity (1, 2,. . ., ≥6); $\beta_6\text{C}_\text{o}$ = fixed effect for the oth previous case background of MF (0/1: absence/presence of previous MF case); $\beta_7\text{L}_\text{p}$ = fixed effect for the pth previous lactation length (12 classes, rounded to the next month, from 4 to 15 and higher); $\beta_8\text{S}_\text{q}$ = fixed effect for the qth previous dry period length (6 classes, rounded to the next month, from 1 to 6 and higher); $\beta_9\text{P}_\text{r}$ = fixed effect for the rth previous 305-d corrected milk yield [7 classes relative to the breed mean (**BM**), with 1/7: ≥1,500 kg below/above BM, 2/6: 1,000 to 1,499 kg below/above BM, 3/5: 500 to 999 kg below/above BM, and 4: <500 kg below/above BM); $\beta_{10}\text{I}_\text{s}$ = fixed effect for the sth length of calving interval (6 clases, rounded to the