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Short communication

Effect of health disorders on the hazard of culling on the first or second lactation in Iranian dairy herds

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ABSTRACT

We conducted a longitudinal retrospective study in order to assess the effect of health disorders (HDs) on culling in the 1st or 2nd lactation cows, in Iranian dairy herds. In total, 7067 first- and second-parity Holstein cows, from 32 Iranian dairy herds, which calved from March 2007 to March 2008, were followed until the next calving or culling. Parametric survival models with time-dependent covariates were used to capture the effect of HDs with different duration and recurrence episodes on the risk of culling. Mastitis, locomotor disorders, ovarian cysts, abortion, diarrhea, rumen disorders, displaced abomasum and respiratory disorders were associated with an increased risk of culling. Hazard ratios and 95% confidence intervals were 2.78 (2.31; 3.35), 3.4 (2.79; 4.13) and 1.62 (1.15; 2.78) for mastitis, locomotor disorders and ovarian cysts as common HDs, respectively. Parity and milk-yield were identified as confounder and effect modifier, respectively. The risk of culling in the presence of uterine infection or traumatic reticulo-peritonitis increased with decreasing milk yield.

1. Introduction

Culling of dairy cows is a costly and complex issue. The frequently reported reasons for culling include low milk yield, lack of conception, availability of replacements, high parity and various health disorders (HDs) (Gröhn et al., 1998; Beaudeau et al., 2000; Hultgren and Svensson, 2009). The largest proportion of the costs associated with culling is due to the purchase of replacement heifers; they are considered to be the second after feed costs (Hultgren and Svensson, 2009). Although HDs and other factors affecting culling decisions have been investigated in other countries (Rajala-Schultz and Gröhn, 1999; Schneider et al., 2007; Cramer et al., 2009), there is an absence of relevant studies for the Iranian dairy industry. Factors identified in other countries can be used as indicators but may not be directly extrapolated to Iran because of differences in management (e.g. due to extended periods of heat stress) and/or the distribution of HDs. Therefore, we conducted a retrospective

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longitudinal study aiming to identify HDs associated with culling in the first or second lactation in Iranian dairy herds. The data were analyzed using survival analysis models with time dependent covariates.

2. Materials and methods

2.1. Study population – inclusion criteria

The study population comprised of a convenience sample: 32 herds with >50 cows [approximately 80% of the Iranian dairy cows are located in herds with this herd size (Iran Ministry of Agriculture, 2006)], located in Tehran province (there are 679 herds with >50 cows in this area), with at least monthly veterinary inspection. The study herds had complete data records on HDs, productive and reproductive performance. Besides, their managers were willing to release the data. Cattle were of Holstein-Frisian breed that calved throughout the year and were bred using artificial insemination. Cows were housed in open-shed barns and milked three times a day. They were offered diets based primarily on corn silage, alfa-alfa hay and concentrate mixes including corn, soybean meal, bone meal and mineral supplements. All cows in the first or second lactation which calved or aborted after more than 180 days of gestation (late abortion) between March, 21st 2007 and March, 20th 2008 were followed up until next calving or late abortion (censored observation) or culling. Cows in the first- and second-lactation in Iran accounted for about two-thirds of the animals in each herd (Iran Ministry of Agriculture, 2006).

2.2. Collection of data on health disorders

The studied herds were visited monthly and the records of the selected cows (either on paper or electronic) were reviewed by the first author. Data on HDs occurrence were based either on veterinary diagnosis or on the farmers' observations followed by veterinary confirmation. The registered HDs (coded as present or absent) were: mastitis, uterine infection, foot and leg disorders, ovarian cysts diagnosed after 40 days post calving, abortion, retained placenta, diarrhea, rumen disorders (i.e. bloat, acidosis, impaction or ruminitis), vaginal disorders (i.e. prolapse, vaginitis, vulvo-vaginitis), left or right displaced abomasum (DA), traumatic reticulo-peritonitis (TRP), traumatic udder injury, respiratory disorders, dystocia, downer cow syndrome, and clinical ketosis. The working definitions for these HDs are in Beaudeau et al. (1994, 1995) and Andrews et al. (2004). Parity, season of calving (Spring: 21 March–20 June, Summer: 21 June–20 September, Fall: 21 September–20 December, Winter: 21 December–20 March) and cumulative milk-yield during the first 60 days of lactation were also retrieved and analyzed as potential confounders (Dechow and Goodling, 2008).

2.3. Statistical analysis

In order to investigate the associations between the HDs and culling, we employed parametric survival models. For each cow, time to event was defined as the time from the beginning of the observation period until culling. Cows that started a new lactation during the observation period contributed a censored observation. These were cows that either calved or experienced late abortion (>180 days of gestation). We adopted a time-dependent covariate approach, which concurrently assessed both the occurrence and duration of the considered HDs. For each observation, we split follow-up time in intervals, each corresponding to a 30-day-long lactation interval (time units). Thus, an animal was assumed to experience a certain disease for 30 days if the disease occurred during an interval. Multiple disease occurrences within the same interval were considered as a single episode, while disease occurrences in different intervals were considered as different episodes.

The selection of the appropriate survival distribution was based on a nonparametric graphical test on the shape of the hazard curve. The plots were compared with the theoretical expectations under six different parametric survival distributions namely, the exponential, Weibull, Gompertz, log-normal, log-logistic, and generalized gamma distribution (Kleinbaum and Klein, 2005). The Gompertz distribution was the most suitable for the analysis of our data. The proportional hazard assumption was graphically evaluated for all candidates to be included in the survival model variables. Graphical checks revealed that any change in the Kaplan–Meier survival estimates with time was approximately parallel for the different levels of each candidate variable. Herd was included as a shared frailty effect term in all models. Under the final model, a likelihood ratio test was used to test the hypothesis that the shared frailty effect term was redundant. The choice between a gamma and inverse Gaussian distribution for the frailty effect term was based on the comparison of the log-likelihoods of the models (Kleinbaum and Klein, 2005).

Initially, correlation analysis of HDs was conducted to identify pairs of variables that essentially contained the same information. When pairs of highly correlated variables were found, selection of the variable to be included in the model was based on biological plausibility. Uni-variable analysis was carried out afterwards to identify HDs that were associated at $P \leq 0.2$ with the risk of culling. Subsequently, all previously selected HDs and the potential confounders were simultaneously offered to a full model which was reduced by backwards elimination of HDs with $P > 0.05$. Each time the reduced model was compared to the full model by means of the likelihood ratio test. The procedure was repeated until all the remaining variables were significant at $P < 0.05$. Finally, a stepwise forward selection process was done by offering previously excluded variables to the final model one at a time and retained if significant.

Lastly, biologically plausible two-way interactions between either the confounders or the HDs or between the HDs were evaluated and retained if significant. Under the final model, the Gompertz distribution had the best fit (i.e. the smallest Akaike's Information Criterion) compared to other previously considered distributions. The fit of the final model was also assessed by use of the Cox-Snell residuals (Kleinbaum and Klein, 2005). Data management and analysis were performed in Stata software

(StataCorp. 2007. Stata Statistical Software: Release 10.1 College Station, TX: StataCorp LP).

3. Results

There were 7067 cows included in the analysis contributing a total of 100,023 time units at risk. Of these cows, 3904 (56.4%) were in the first and 3163 (43.6%) were in the second lactation. In total, 22.1% cows were culled. These were 18.4 and 26.6% of the first and second parity cows, respectively. The incidence rates (new cases per cow-month at risk) for the three most common HDs were: for culled cows – mastitis 0.051 (0.047; 0.055), uterine infection 0.038 (0.035; 0.042), locomotor disorders 0.037 (0.034; 0.041); for censored cows – mastitis 0.024 (0.023; 0.026), uterine infection 0.016 (0.015; 0.017), locomotor disorders 0.015 (0.014; 0.016). Estimated hazard ratios (HR) and associated 95% confidence intervals (CIs) under the final multivariate model are in Table 1. Second parity cows had a higher risk of culling and the risk increased with decreasing milk production. Locomotor disorders, mastitis, ovarian cyst, abortion, uterine infection, diarrhea, rumen disorders, DA, TRP and respiratory disorders were associated with increased risk of culling. Cows with diarrhea posed the highest risk [HR = 10.56; 95% CI = 8.07; 13.82)] of being culled earlier in their life, while cows with cystic ovaries had the lowest risk [HR = 1.62; 95% CI = 1.15; 2.78)]. The risk of culling in the presence of uterine infection or TRP increased with decreasing milk yield.

4. Discussion

We employed a parametric survival model with time-dependent covariates to investigate the effect of several HDs on the risk of culling, in Iranian dairy cows. Estimates were based on a convenience sample of 32 herds, which corresponds to approximately five percent of the herds located in the Tehran province with >50 cows. The risk of culling increased with parity and decreased milk production; however, it was not associated with calving season. Furthermore, milk production modified the effect of uterine infection and TRP on the risk of culling. Lower milk production coincides with increased risk of culling due to TRP and uterine infection (Beaudeau et al., 1994, 1995). Ovarian cysts and abortion were associated with increased risk of culling (Beaudeau et al., 1994, 1995, 2000; Gröhn et al., 1998). In accordance with previous reports (Gröhn et al., 1998; Rajala-Schultz and Gröhn, 1999), we found a positive association between mastitis and culling. Mastitis was the most frequently recorded HD among either culled or censored cows. In previous studies, udder disorders and especially mastitis were the most frequent reasons for health-related culling (Rajala-Schultz and Gröhn, 1999; Schneider et al., 2007). Locomotor and respiratory disorders increased the risk of culling. Some authors found that locomotor disorders were associated with shorter time to culling (Rajala-Schultz and Gröhn, 1999; Cramer et al., 2009), while others reported no association (Beaudeau et al., 1994, 1995). Respiratory disorders were rarely considered in models of health-related culling reasons. Dohoo and Martin (1984) also reported an increased risk of culling

Table 1
Estimated hazard ratios (HRs) and CIs for health disorders (HDs) and the possible confounders associated with time to culling, under a parametric Gompertz survival model with the inclusion of shared frailty effect term on herd. Estimations were based on data of 7067 Iranian dairy cows reared in 32 dairy herds that calved between 21st March 2007 and 20th March 2008.

Variable	HR	CIs	*p*-Value
Parity			
1	1	–	–
2	1.37	1.24; 1.52	<0.001
60-d cumulative milk yield			
>2100 lit.	1	–	–
1801–2100 lit.	2.37	1.77; 3.16	<0.001
1501–1800 lit.	4.88	3.64; 6.52	<0.001
<1500 lit.	6.40	4.82; 8.50	<0.001
HDs			
Mastitis			
Yes	2.78	2.31; 3.35	0.001
No	1	–	–
Locomotor disorders			
Yes	3.40	2.79; 4.13	<0.001
No	1	–	–
Ovarian cysts			
Yes	1.62	1.15; 2.78	0.006
No	1	–	–
Abortion			
Yes	2.19	1.60; 3.02	<0.001
No	1	–	–
Diarrhea			
Yes	10.56	8.07; 13.82	<0.001
No	1	–	–
Rumen disorders			
Yes	5.44	3.79; 7.81	<0.001
No	1	–	–
Displaced abomasum			
Yes	3.83	1.89; 7.79	<0.001
No	1	–	–
Respiratory disorders			
Yes	5.17	2.87; 9.30	<0.001
No	1	–	–
Presence of uterine infection × 60-d cumulative milk yield			
>2100 lit.			
Yes	5.78	2.47; 13.5	<0.001
No	1	–	–
1801–2100 lit.			
Yes	8.55	4.39; 17.69	<0.001
No	1	–	–
1501–1800 lit.			
Yes	10.96	6.23; 20.80	<0.001
No	1	–	–
<1500 lit.			
Yes	12.44	7.66; 22.60	<0.001
No	1	–	–
Presence of TRP × 60-d cumulative milk yield			
>2100 lit.			
Yes	9.02	5.29; 15.37	<0.001
No	1	–	–
1801–2100 lit.			
Yes	11.50	7.07; 19.80	<0.001
No	1	–	–
1501–1800 lit.			
Yes	13.97	8.94; 22.61	<0.001
No	1	–	–
<1500 lit.			
Yes	15.51	10.12; 24.62	<0.001
No	1	–	–
Variance estimate			
Herd-level variance	0.05	0.021; 0.10	<0.001
Hazard shape parameter			
Gamma	0.0014	0.0011; 0.0016	<0.001

for cows with respiratory disorders. All considered digestive disorders were significantly associated with the risk of culling. The association between DA and the risk of culling is already reported (Gröhn et al., 1998; Rajala-Schultz and Gröhn, 1999). Low yielding cows has increased risk of culling due to TRP. Costs and prognosis associated with TRP treatment coupled with low milk yield, favor culling of affected cows. Diarrhea was strongly associated with the risk of culling. Although diarrhea is a non-specific index of digestive disorders, paratuberculosis is considered a major problem in Iranian dairy cows and has been associated with an increased risk of culling in dairy cows (Raizman et al., 2007).

We identified several HDs which affected the culling decisions of Iranian farmers. The estimated HRs indicated different strength of association between the HDs and the risk of culling. For decreasing the overall risk of culling in Iranian dairy herds, prioritization of interventions against the identified HDs should consider not only the estimated HRs but also the incidence of the disorders in the target population.

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