



Risk factors for on-farm mortality in beef suckler cows under extensive keeping management

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ABSTRACT

The on-farm mortality of cows in cow-calf herds has a significant influence on the economic efficiency of the farm. It is also an indicator of suboptimal animal health and welfare. The present study analysed the registry data of beef cows in Estonia from the years 2013 to 2015. The datasets incorporated 8084 parturitions of primiparous cows and 21,283 parturitions of 9234 multiparous cows. A Weibull proportional hazard random effect model was used for risk factor analysis, in which the on-farm mortality, including death and euthanasia, was the event of interest.

The first 30 days post-calving were associated with the highest mortality hazard for primiparous and multiparous cows (including 28.9% and 21.1% of deaths, respectively).

In multiparous cows, the lowest mortality hazard was confirmed for animals with parity of three to five, increasing significantly after that. Primiparous cows that did not have a stillborn calf had a significantly higher mortality hazard when calving over 44 months of age compared to cows calving younger than 36 months. Stillbirth and abortion were significant risk factors for mortality. Cows with dystocia experienced a higher mortality hazard, especially during the first week post-calving. In multiparous cows, a higher herd mean age at first calving was associated with a higher mortality hazard.

This study highlights the fact that the early post-partum period and factors associated with calving, such as age at first calving, dystocia, stillbirth and abortion, are critical for beef cow survival.

1. Introduction

Cow-calf production is expanding steadily in Estonia. In 2015, there were 25,023 registered suckler cows, which was 8.6% more than those registered in 2014. The number of cow-calf producers increased from 1481 in 2014 to 1593 in 2015 (Estonian Agricultural Registers and Information Board, 2016). Estonia is a country with low human population density and availability of ample agricultural and grasslands. After the considerable decline in milk prices in European market in autumn 2014 (Eurostat, 2017), the number of dairy farms forming a predominant branch of cattle farming in Estonia has decreased considerably (Estonian Agricultural Registers and Information Board, 2016). Since then, many farmers have shifted from dairy to beef production due to the availability of natural resources supporting cattle raising. Although limited information is available about the characteristics and management of beef herds, it is known that extensive cow-calf production with pasture-based feeding is the predominant production system for beef cattle in Estonia. In beef production systems, the longevity of breeding stock has a substantial effect on economic

efficiency (Rogers et al., 2004). Longevity of cows is associated with a smaller requirement of replacement animals, resulting in lower cost per animals produced. Longevity is also related to voluntary and involuntary culling defined as removal of a live cow from the farm for immediate slaughter (Compton et al., 2017). Mortality (death of an animal on the farm, whether euthanized or unassisted) (Compton et al., 2017) of an animal is always an unexpected and undesirable event. In addition to the economic consequences, mortality is an indicator of poor animal health and well-being (Ortiz-Pelaez et al., 2008).

In beef cattle previous research has found that the highest mortality risk is directed at young calves (Perrin et al., 2012; Pannwitz, 2015), which is the reason for dedicating a considerable amount of research to that age group, while fewer studies have described mortality in beef cows and heifers (McDermott et al., 1991; Menzies et al., 1995; Dutil et al., 1999; Waldner et al., 2009; Perrin et al., 2012; Pannwitz, 2015). Even less is known about the risk factors affecting beef cow mortality. Age, herd size, region, season and conditions related to calving (Menzies et al., 1995; Waldner et al., 2009; Perrin et al., 2012; Pannwitz, 2015) are usually associated with an increased mortality of

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beef cows. Complementary risk factor studies are warranted to clarify the factors influencing mortality risk in order to provide recommendations for targeting lower mortality in suckler cows.

The aim of this study was to analyse the association between on-farm mortality of suckler cows (natural death and euthanasia) and animal and herd-level factors using data registered by the animal performance registry.

2. Materials and methods

2.1. Data sources

In Estonia farmers are obligated to report births, movements and exits of animals on a routine basis (EC 1760/2000). In addition, during the last 10 years, beef cattle keepers could participate in the animal performance recording system held by the Estonian Livestock Performance Recording (ELPR) Ltd. (Recording Centre). The ELPR collates individual and herd data and produces summary statistics of participating herds.

The data were inquired for the period from 1 January 2013 to 31 December 2015 for animals kept in herds with over 10 cow-years for each of the 3 study years. Although the data of the ELPR include dates and farmer's stated reasons for animal exits, the database contains no information about whether the animal died, was sold or was slaughtered. In order to combine the exit events with the mortality (unassisted death and euthanasia), the respective information was collected from the Estonian Agricultural Registers and Information Board (Animal Register) and was merged with the ELPR data. Estonian farmers have an obligation to report all events related to animal movements, deaths and slaughters within 7 days to the Animal Register (EARIB; Riigi Teataja, 1999). For the Recording Centre, the deadline for notifications is longer and not strictly specified. For that reason, a difference of up to 7 days was allowed between the dates of the two datasets to occur when matching the exit events with mortality events. According to the EARIB, there were 1479 animal keepers whose herd type could be classified as beef herd according to the definition of a minimum of 75% of their animals being beef breed. The data extracted from the ELPR database included individual cow data of all the participating farms meeting the herd size criteria, including 184 herds; therefore, the present study included around 12.5% of the beef cattle keepers in Estonia.

2.2. Datasets

The study included data of all beef cows present in herds that participated in the beef cattle production recording system administered by the Recording Centre between 1 January 2013 and 31 December 2015. Separate datasets were composed for primiparous and multiparous cows. Data on birth and exit dates, age at first calving, information about the farms (individual number and location) in which the animal was born and kept, breed details and birth weight of the cow were requested. Also, information about the parity, calf birth weight, presence of dystocia, stillbirth or abortion were included for each calving. Summarised data of the herd was also requested for each study year including herd's location, yearly number of cow-years in a herd, average age at first calving, average calving interval, number of not-calving cows, number of first calving cows, number of purebred cows, bulls and heifers, number of heifers, young bulls and breeding bulls (total number of animals was given according to status at 31st of December of the corresponding year), number of stillbirths (calves born dead, or dead within 24 h after birth, after 210 days of pregnancy) and abortions (calves born dead within < 210 days of pregnancy) (ELPR Dairy Cattle Recording Handbook, 2015) as well as average heifer and bull calf birth weights (Tables 1A and 1B). Three years' averages were calculated for the main herd-level indices.

2.3. Statistical analyses

The associations between potential risk factors and on-farm mortality were analysed using the Weibull proportional hazard model with gamma frailty effect. The parametric survival model was preferred over semi-parametric Cox model due to its applicability to large datasets. Parametric models with different distributions were compared according to their information criteria values, and Weibull distribution was chosen due to lowest Akaike information criteria (AIC) and Bayesian information criteria (BIC) values of the models. Models with gamma distributed frailty were compared with inverse Gaussian distributed frailty, and the former was preferred due to lower Information Criteria values.

The observation period for the cows was from calving to next calving. Each calving during the study period started a new observation period for the animal. In order to consider left truncation in the analyses, the option 'enter' specified the date the animal entered the study when declaring data to be survival-time data (*stset* command in Stata®) (Cain et al., 2011). The 'enter' date was (i) 1 January 2013 for animals that were present in a population on that date, (ii) calving date for animals that calved between 1 January 2013 and 31 December 2015 and (iii) date of purchase for introduced animals. Animals contributed time at risk from the start of the study period until the next calving, failure or right censoring. Animals that were sold or slaughtered during the study period were regarded as censored in the survival analysis. Observations were also right censored in case the calving had not occurred before 31 December 2015. The event of interest, specified as 'failure' in the *stset* command, was unassisted death or euthanasia occurring in the farm. In order to avoid exclusion of the observations that started and ended on the same day, half a day was added to exit dates for all observations. The data of multiparous cows were declared to include multiple records per individual by specifying the 'id' option in the *stset* command.

2.4. Variable selection

Initially, univariable associations between predictor variables and mortality as an outcome were detected with univariable random effects Weibull models. The general equation of the Weibull models was as follows:

$$h_i(t | \alpha_i) = \lambda p t^{p-1} \cdot e^{\beta X_i \alpha_i}$$

in which the hazard of an individual at time t is $h_i(t | \alpha_i)$; λ is the scale parameter; p is the shape parameter; βX is the effect of the variable (multiple variables included in the multivariable model); α is the frailty on the hazard scale.

The model of primiparous cows included a 'herd' random effect, and a shared frailty effect for 'cow' was also introduced into the multiparous cow model.

Variables with a liberal p -value < 0.25 were considered for multivariable analysis. A causal diagram was composed to detect the causal associations between variables and detect possible confounders. Collinearity between predictor variables was ascertained according to the variance inflation factor (VIF) statistics (Dohoo et al., 2009). The collinearity was initially evaluated for continuous predictors and categorical predictors were included one at the time as suggested by Murray et al. (2012). The value of VIF over 10 was considered to indicate a collinearity (Dohoo et al., 2009) and the variable was removed in case there was also a biological sense in explaining the collinearity (O'Brien, 2007).

2.5. Multivariable modelling

2.5.1. Variable reduction

A manual backward elimination method was used to exclude insignificant ($p > 0.05$) variables from the multivariable model. In case

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