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Factors affecting non-return rate in dairy cattle

D.L. JOHNSON

Livestock Improvement Corporation, P.B. 3016, Hamilton

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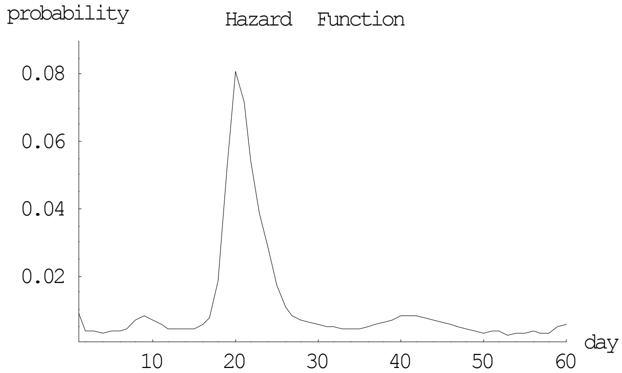
Non-return rate (NRR) to artificial insemination (AI) gives a measure of bull fertility early in the mating season. Calving rate can be biased due to culling and is available too late in the season to be useful for detecting sub-fertile bulls. A current limitation, in the New Zealand dairy industry, to calculating the NRR for bulls is that it is largely based on raw averages of binary data (returned or not) and using only qualifying matings. For example, for an 18-24 day NRR, a mating would qualify if the insemination occurred at least 24 days prior to the end of the observation period and this would utilise only about 42% of the available mating information. Currently no account is taken of environmental factors that may affect NRR (e.g. region, breed of cow) and of the number of inseminations for each bull.

The variable of interest is the time interval between the mating date for a cow and an end-point. For a cow returning to service during the AI mating period, the end-point is the date of return to service. For non-returns within the mating period, the end-point is the final AI mating date for the herd. The former type of mating record is uncensored while the latter is a censored record in the sense that a possible return event may not be observed.

Survival analysis (e.g. Klein & Moeschberger, 1997; Ducrocq, 1999) was used to analyse the return interval data. The hazard function measures the instantaneous probability of return to service at a specified day post-mating, given non-return up to that point of time. Figure 1 shows the typical form of hazard function for the return interval data. This graph is based on the 2001 spring-mating season, the data from the national dairy database comprising approximately 3 million AI matings per year. There is a large peak in the risk of returning to service at about 21 days after mating and a smaller peak at 42 days. Similar to the Australian study (Carrick *et al.*, 1999) there is a small peak at day 9 coinciding with reported increases in ovarian follicular activity and oestrogen secretion around this time. The small peak at day 1 corresponds to cows inseminated on two consecutive days. The hazard function is estimated using a semi-parametric approach (Cox model) because the common survival distributions (e.g. Weibull) are not suited to fit the shape shown in Figure 1.

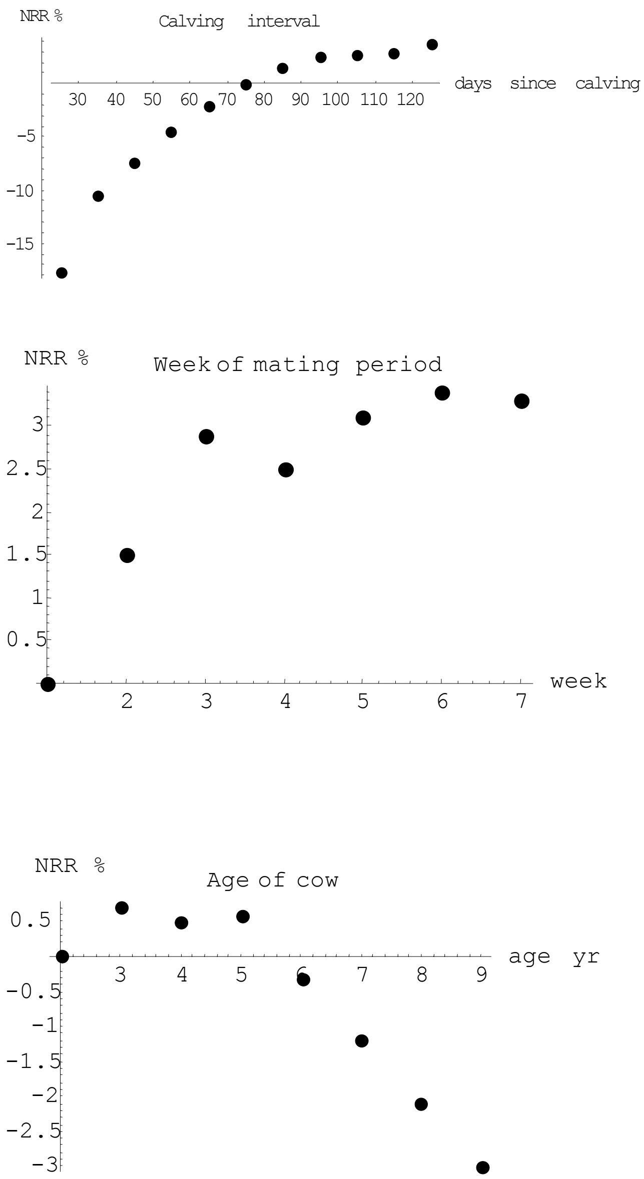
FIGURE 1: Hazard function - probability of return to service by day post-mating conditional on non-return up to that point of time.



A proportional-hazards model allows one to relate the hazard to a set of explanatory variables such as the environmental factors mentioned above. If $h_0(t)$ represents the baseline (or 'average') hazard function, then the hazard for an individual with factor set **x** at day *t* is given by $h(t;\mathbf{x}) = h_0(t)\exp(\mathbf{x}'\beta)$. The exponential term (the parametric part of the model) acts multiplicatively on the baseline hazard and the exponent $\mathbf{x}'\beta$ is a linear model. The following factors affecting non-return rate were included as fixed effects in the linear model: region, cow breed, cow age, bull breed, semen brand, semen age (liquid semen), semen concentration (proven sires), days since calving, calving difficulty, induction, week of mating, and anoestrus treatment. In addition, the effects of mating bull, inseminating technician and herd were included as random effects in order to measure the variation due to these effects and their influence on the hazard function. It follows from above that a NRR for an individual with factor set **x** can be expressed in terms of the baseline NRR by $NRR_x = (NRR_0)^{\exp(\mathbf{x}'\beta)}$.

Results are expressed on the NRR scale (% cows not returning to insemination). For bull breed, relative to Holstein-Friesian(HF) as the base, the NRR was +0.2% for Jersey (JE), -1.0% for Ayrshire (AY) and +0.8% for Friesian-Jersey crossbred (FJ) semen. For cow breed, relative to HF as base, JE cows were –3.6% and FJ cows –1.4%. There was a downward trend in NRR from northern to southern regions of up to 4%. Anoestrus-treated cows had a 2.2% lower NRR than untreated cows and induced cows were 3.2% lower than non-induced cows. Cows with minor or major calving difficulty had a 3.3% or 5.3% lower NRR respectively compared to cows that were reported as requiring no assistance or were unrecorded for calving difficulty. For liquid semen there was a downward trend in NRR for increasing semen age and an upward trend for increasing semen concentration. Other estimates are depicted in Figure 2. Relative to 2-yr old cows, 3-, 4- and 5-yr old cows had higher NRR which then steadily decreased for older cows. NRR increased with the length of the interval since calving and increased over the first three weeks of the mating period. For random effects, the range (±2 SD) of NRR estimates was ±3% for bulls within breed, ±5% for technicians and ±10% for herds

FIGURE 2: Estimated effect on NRR(%) of days since calving, week of mating period and age of cow.



Calving data provides another measure of returns within the limitations of culling in commercial herds and provides a reality check for the NRR analysis. We denote this binary trait of non-return rate based on calving as NRRC. A successful mating (non-return) was indicated if the gestation length satisfied acceptance limits and was the only mating for that cow to do so. Matings were deleted where a cow calved but the successful mating could not be determined and were also deleted for cows that had abortions or premature calvings. Matings for cows with induced calvings were treated as unsuccessful as the successful mating would be expected to have occurred after the AI mating period . Mating records from herds with calving rates below 50% were deleted. Estimates of the environmental effects in the NRRC analysis followed closely the patterns observed in the NRR survival analysis described above. Bulls with at least 10,000 inseminations gave a rank correlation of 0.87 between NRR and NRRC evaluations. If the NRR analysis was based on the binary score using qualifying matings (only 42% of the return interval data) the rank correlation reduces to 0.75 demonstrating the added value of the additional information used in the survival analysis.

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