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The optimal number of heifer calves to be reared as dairy replacements

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ABSTRACT

Dairy farmers often keep almost all their newborn heifer calves despite the high cost of rearing. By rearing all heifer calves, farmers have more security and retain flexibility to cope with the uncertainty in the availability of replacement heifers in time. This uncertainty is due to mortality or infertility during the rearing period and the variation in culling rate of lactating cows. The objective of this study is to provide insight in the economically optimal number of heifer calves to be reared as replacements. A herd-level stochastic simulation model was developed specific for this purpose with a herd of 100 dairy cows; the biological part of the model consisted of a dairy herd unit and rearing unit for replacement heifers. The dairy herd unit included variation in the number of culled dairy cows. The rearing unit incorporated variation in the number of heifers present in the herd by including uncertainty in mortality and variation in fertility. The dairy herd unit and rearing unit were linked by the number of replacement heifers and culled dairy cows. When not enough replacement heifers were available to replace culled dairy cows, the herd size was temporarily reduced, resulting in an additional cost for the empty slots. When the herd size reached 100 dairy cows, the available replacement heifers that were not needed were sold. It was assumed that no purchase of cows and calves occurred. The optimal percentage of 2-wk-old heifer calves to be retained was defined as the percentage of heifer calves that minimized the average net costs of rearing replacement heifers. In the default scenario, the optimal retention was 73% and the total net cost of rearing was estimated at €40,939 per herd per year. This total net cost was 6.5% lower than when all heifer calves were kept. An earlier first-calving age resulted in an optimal retention of 75%, and the net costs of rearing were €581 per herd per year lower than in the default scenario. For herds with a lower or higher culling rate of dairy cows (10 or 40% instead of 25% in the default scenario), it was optimal to retain 35 or 100% of the heifer calves per year. Herds that had a lower or higher cost of empty slots (€50 or 120 per month instead of €82 in the default scenario) had an optimal retention of 49 or 83% per year; the optimal retention percentage was dependent on farm and herd characteristics. For Dutch dairy farming conditions, it was not optimal to keep all heifer calves.
Key words: dairy replacement, young stock rearing, culling, cost

INTRODUCTION

Most Dutch dairy farmers, and many farmers in other major milk-producing countries, rear their own young stock to provide replacement heifers. Heifer rearing is expensive, with high costs for feed, labor, and housing (Gabler et al., 2000; Tozer and Heinrichs, 2001). Recent estimates of the cost of rearing a replacement heifer in the Netherlands range between €1,400 and 1,700 per heifer (Mohd Nor et al., 2012).

Farmers are aware that heifer rearing is expensive, but they still keep (almost) all their newborn heifer calves to ensure enough young stock are available to replace culled dairy cows. When too much young stock is kept, they are sold to other farms or sold for export. The uncertainty in the availability of full-grown heifers occurs due to mortality and growth and reproduction problems in the rearing period. The risk of mortality of calves after birth was reported to vary between 1 and 8% (Svensson et al., 2006; Mee, 2008; Raboisson et al., 2013). Growth and reproduction problems (e.g., infertility) reduce the number of heifer calves reaching their first calving because these heifers have either a higher probability to be culled during rearing (Hultgren et al., 2008; Brickell et al., 2009; Brickell and Wathes, 2011) or a high first-calving age (and therefore delayed availability for replacement). Mohd Nor et al. (2014) reported that the average culling rate of lactating cows in Dutch dairy herds was 25%, ranging between 23 and 28% in different years. For individual herds, the variation between years was even higher. There are several reasons why the culling rate varies between years. One potential reason is an outbreak of an endemic disease,

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such as bovine viral diarrhea or infectious bovine rhinotracheitis (Vonk Noordegraaf et al., 1998).

Various studies have evaluated the costs of heifer rearing (Gabler et al., 2000; Mohd Nor et al., 2012), the mortality of heifer calves (Svensson et al., 2006; Raboisson et al., 2013), and the culling of dairy cows (Pinedo et al., 2010; Mohd Nor et al., 2014). All this information is needed to determine the optimal number of heifer calves to be reared as replacements for culled dairy cows. No study, however, has incorporated the uncertainty of losing heifer calves and variation in the culling rate of dairy cows to determine the optimal number of replacement heifer calves. In addition, the economic consequences of keeping too few or too many heifer calves have not yet been investigated.

The objective of the current study was to provide insight on the economically optimal number of heifer calves to be reared as replacement heifers to support tactical management decisions. We developed a stochastic model that determined the optimal number of heifer calves to be reared by minimizing the net cost of rearing replacement heifers. The model included uncertainty in the mortality and fertility of heifer calves and the culling rate of dairy cows.

MATERIALS AND METHODS

Model Development

To determine the optimal number of heifer calves that should be retained to replace culled dairy cows, a herd-level Monte Carlo simulation model was developed in Microsoft Excel (Microsoft Corporation, Redmond, WA,) using @Risk add-on software (Palisade Corporation, Ithaca, NY). The settings of the model were chosen to represent a Dutch dairy herd that rears its own replacement heifers.

The model simulated both the dairy herd unit and the young stock rearing unit of the herd. A closed herd (i.e., no purchase of cows and calves) was assumed. Moreover, a management approach ensuring good herd health was assumed. The model was simulated with monthly time steps (stages), and included 83 monthly stages. As the transportation of newborn calves before the age of 2 wk is prohibited in the Netherlands, an additional stage was defined to capture these first 2 wk, resulting in a total of 84 stages. Each replication covered in total a period of 7 yr, and started with a herd of 100 dairy cows and no heifer calves present. At every stage, there are several young stock with an age varying between 2 wk to first calving age. When the decision was made to retain all heifer calves, after the third year, the model reached the steady state. Thus, the average result for yr 3, 4, 5, 6, and 7 was similar. When the decision was made to keep fewer heifer calves, the model showed that it reached a steady state at yr 7. The economic analysis was therefore based on the simulated results of yr 7. This has also allowed the simulated system to achieve a stable herd structure in accordance with the simulated scenarios (described in the next section).

In the dairy herd unit of the simulation model, the number of calvings and subsequent number of newborn heifer calves was simulated for each stage by using binomial distribution, based on the herd size, calving interval, and the male-to-female ratio. The number of culled dairy cows was also simulated for each stage by using the binomial distribution.

In the rearing unit, the following states were defined: dead, inseminated, pregnant, infertile, and first-calving age. At each stage, the number of heifers in each state was simulated by using binomial distribution. A replacement heifer was defined as a reared heifer that had reached first-calving age.

At each stage, the heifer-rearing unit and the dairy herd unit were linked by comparing the number of available replacement heifers in the heifer rearing unit with the number of culled dairy cows in the dairy herd unit. Available replacement heifers filled up the slots that were left empty when dairy cows were culled. If no replacement heifer was available to replace a culled dairy cow, the herd size was temporarily reduced, which resulted in an empty slot for at least 1 mo. If more replacement heifers were available than required (i.e., the herd size had reached 100 dairy cows), the redundant replacement heifer was sold as an excess heifer.

The model contained a large number of possible combinations of states at each stage. Therefore, 10,000 replications were carried out to provide stable results and insight into the possible range of outcomes. Inputs were based on relevant scientific literature where available, followed by information from organizations and experts active in the Dutch dairy industry. If no information was available, the authors' expertise was used.

Biological Input. The number of calves born was specified as a binomial distribution, with the herd size and calving interval as input. The probability of a female calf was assumed to be 50%. The number of culled dairy cows was specified as a binomial distribution with an average culling rate of dairy cows of 25% as input (Table 1).

Within the rearing unit, the number of calves that died per stage was also specified as a binomial distribution, using the number of calves in that stage and a stage-specific probability of death (Table 1) as inputs. The BW of heifers during the rearing period was based on Koenen and Groen, (1996; Table 1). The process of insemination was started at the age of 15 mo; we