Challenging the norm – cull rates and farm economics

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Abstract

Culling has often been seen as removal of cows from the herd that were either too broken or did not pay for their feed cost anymore. This norm on cull rates may be challenged in several different ways. First, cow replacement rates are primarily the result of how many heifers have been raised to enter the herd. In closed herds, this decision starts at breeding with the assignment of semen types (sexed or conventional, dairy or beef) some 33 months before the heifer calves. Second, continuous improvements in health, fertility and milk production through management and genetics remain important. This makes for more profitable cows that can stay in herds longer. However, if there is sufficient variation among cows, it will remain a good decision to replace the least profitable cows sooner rather than later. A longer productive life (lower replacement rate) is therefore not necessarily better. Third, there is still quite a bit of work to be done to better support the most profitable replacement decisions. Better replacement decisions, in turn, will drive how many heifers are needed and therefore what the optimal cull rate will be.

Key words: cow replacement, economics, decisions

Introduction

How long cows should stay in herds has been a topic of considerable interest in the last decade[6,7,17] but is not a new topic.[11,13] There are several reasons for this. The commercial availability and wide use of sexed semen in the last 15 years has allowed dairy farmers to make an abundance of dairy heifer calves. This has made dairy farmers wonder if they possibly could have too many heifers, and what the ideal number would be. Couple this with the now also wide-spread use of beef semen in dairy cows, and dairy producers question how many dairy heifer calves vs. beef-on dairy calves they should make. These options also have made the industry more aware that how long cows stay in the herd on average is primarily a function of how many heifers are available and brought into the herd. When the dairy farm stays at a constant cow herd size, a cow must leave to make room for a calving heifer. The rapid improvements in fertility, milk production and cow comfort also lead to questions about the criteria dairy producers should use to rank and sell cows. Perhaps the old norm that cow replacement (culling) is something that overcomes us, is changing more into the idea that replacement (cull) rates are more under control than previously thought. All these aspects are related and make for a complicated but fascinating puzzle.

In the US, this puzzle is currently primarily one of economics and maximizing dairy profitability. Outside the U.S., other drivers play a greater role in ideas on how long cows should stay in herds.[8,13] For example, the observation that it may be good for consumer perception of dairy farming that cows have long lives and therefore the cull rate is low. And the assertion that cows that live long improve the environmental sustainability of dairy farming. Both these drivers deserve more nuance than typically given but are not addressed in this paper.

This paper focuses on economic decision making around cow replacement. Some terminology first. Longevity is the general idea of a long life. Culling is removal from the herd when it is decided that the cow has no future as a milk producing cow. Marketing is likely a better term for culling because most cows are sold for beef to enter the food chain. Productive life is the time from first calving to culling or death. It is calculated as 1/annual replacement rate in a same size herd. Cull rate is understood here to be the annual cow replacement rate if it includes death loss. Cull rates and replacement rates are used interchangeably in this paper, but sometimes slightly different definitions have been proposed as well.[12]

Replacement rates

The annual cull rate in 2,667 DHI herds with at least 100 Holsteins was 37% as measured in August 2024.[10] This number includes death rate. A 37% annual cull rate implies 1/37% = 2.7 years of productive life. This average productive life has decreased in the last 70 years. Seath[18] in 1940 reported productive lives from multiple studies to range from 3.17 years to 4.34 years (equivalent annual cull rates from 32% to 23%). More recent CDCB reports, also calculated from DHI data, show that the percentage of Holstein cows not reaching the next lactation increased from 32% in 2008 to 36% in 2021.[2] Of the first parity cows, 23% did not reach the next lactation in 2008 and this was 28% in 2021. The risk of not completing the next lactation increases with parity. In 2021, it was 32%, 40%, 49%, 57% and 65% for parties 2 to 6, respectively. These risks were generally slightly lower in previous years. The latest revision of USDA's Net Merit selection index[19] reduced the average productive life from 2.8 lactations in 2018 to 2.69 lactations in the 2021.

Parity, not getting pregnant, and diseases are major risk factors for culling.[7] Low genetic merit is also an important risk factor, as genetic audits show. Most cows are culled because there is something wrong with them. It includes (relatively) low milk production in non-pregnant cows that no longer pay their feed cost. Yet most cows are likely culled when they are still profitable.

Some major drivers of the economics of productive lifespan are herd replacement cost, opportunity cost of maturity in milk production and genetic improvement, and the value of calves. It is possible to express these factors in a cost per cow per year. The objective then is to minimize the total cost per cow per year. In this simple analysis,[6] a longer productive life reduces the annual herd replacement cost and increases the fraction of mature cows in the herd. A shorter productive life increases the average genetic merit of the herd and may increase the value of calves. There are trade-offs. The results from this simple analysis[6] show that the increased genetic merit of dairy heifers does not warrant a short productive life. This is in agreement with an earlier literature review[5]. On the other hand, the results of this simple analysis do not consider the opportunity cost of keeping low-producing cows in the herd too long.

Genetically, the trait productive life was added to the Net Merit selection index in 1984.[19] This trait essentially gives credit to sires whose daughters stay longer in the herd than the daughters of other sires. The genetic trait productive life is essentially a reflection of healthy cows.

Since 1990, 12.5 months of breeding value for productive life have been added to the average cow.[1] This implies that the average cow can stay one year longer in the herd. Assuming, for example, that the average annual replacement rate in 1990 was 35% (34.3 months of productive life), this added 12.5 months of productive life might have been expected to result in 46.8 months of productive life, the equivalent of a 26% annual replacement rate. Clearly, this long of a productive life is not observed in practice, as for example, the DHI data above shows. It is therefore questionable, and a topic of debate and investigation, if improving herd health will increase average productive life. Keep in mind that a longer productive life should not necessarily be the goal when maximizing profitability.

The fact that increased breeding values for productive life are not translated into lower replacement rates goes together with the observation that the number of heifers entering the herd is really what drives the average productive life. For every heifer that calves, a cow must leave. In closed herds, this decision starts at breeding with the assignment of semen types (sexed or conventional, dairy or beef) some 33 months before the heifer calves.

Some reasonable explanations of observed replacement rates are that dairy producers cull cows that either no longer pay their variable cost and are not expected to do so in the future, or they cull the least profitable cows because a more profitable replacement heifer is entering the herd, or the norm is that cull rates should be in the mid-thirties. The next section attempts to describe the economic principles of cow replacement more fully.

Economic replacement principles

Assuming a fixed number of dairy cows on the farm, each one occupying a slot (space) on the farm, then a reasonable objective is to maximize profitability per slot per unit of time. This is done by keeping the cow currently in the slot until some time into the future when the decision to replace her will yield a greater average profit of that slot over time than keeping the incumbent cow longer. The view taken here is one of long-time average profitability of the slot, in contrast to a high temporary profit that can be obtained by selling the cow and not replacing her.

An optimal replacement policy maximizes profit per slot per unit of time. Such an optimal policy keeps the current cow until the optimal time to replace her, typically assumed to be a calving replacement heifer.[14] This is done, in principle, by calculating the net present value of the expected future cash flows from keeping the cow until the optimal time in the future (Keep) and compare that value with the net present value from replacing the cow now with a replacement heifer (Replace). The difference, Keep - Replace, is the economic value of keeping the current cow in the herd today. In scientific literature, this difference is called the retention pay-off or future value.[4] I will refer to this difference as the keep value. If the keep value is negative, then the cow should be replaced now.[4,9,13,14] A negative keep value is the opportunity cost of delaying replacement of the cow until the next decision time. If this next decision time is soon, for example next week, then the opportunity cost cannot be large because the cow would be replaced next week if cash flows are truly maximized.

Calculating future cash flows is easier said than done. One hurdle is the mechanics of the calculation of future cash flows, including those of replacement animals, far enough into the future such that all cash flow consequences of today's replacement decision are included. This typically required calculating future cash flows of the current cow and her eventual replacements more than five years into the future. Another aspect is whether replacement decisions in the future should be optimized or are given. For example, we can have a given policy to keep an open cow until her milk yield no longer covers her feed cost (usually this is too long). Or we can have an algorithm to determine how long to keep the open cow until the optimal time of replacement.

To make optimal decisions in the future, the technique of dynamic programming has been used to make optimal sequential cow replacement decisions.[13,9] This was an active scientific area in the 1980s and 1990s. Early applications of the dynamic programming technique to cow replacement decision making were hampered by limited computer capabilities. However, computing capability is no longer a serious limiting factor for the application of these algorithms.

The major hurdle to making better replacement decisions is the complexity of unbiased and accurate predictions of future cow performance, including milk production, fertility, disease risk etc. of each cow currently in the herd and the average replacement heifer. For example, a cow's future cash flow is greatly affected by the milk production we expect in the remainder of her lactation and in future lactations. Her past milk production can help to predict her future milk production, but prediction of milk production is notoriously difficult, especially early in lactation. Historical records may be biased because only survivor cows contributed data to them.[15] The effects of past and current health problems on future cow performance need to be estimated, such as the effects of mastitis and lameness on milk, reproduction. Another challenge is the lack of computerized data that affect future cash flows, such as body weights, body condition scores, milk components, and type traits like udder functionality. If such data are already captured, they may exist in separate databases that are not connected. Further, genetic selection in the era of genomics is changing the dairy cow rapidly. For example, the average heifer is expected to be $150 more profitable in her lifetime than the average heifer one year ago.[1] Another problem for accurate estimation of future cash flows is changing prices, such as for milk, feed, calves, sales, etc. These prices affect future cash flow projections, and the ranking of cows for culling decisions.

Figure 1 is an illustration of keep values over time for a high, average and low producing cow. If the cow does not conceive, then the keep values keep decreasing until at some day after calving the keep value decreases below $0 and it is optimal to replace the cow with a heifer. Pregnancy protects against culling because the keep value remains above $0. The low producing cow has less time to get pregnant than the higher producing cows before her keep value falls below $0.

Figure 1: Illustration of the course of keep values (also known as Retention Pay-offs) for a high, average, and low producing cow. The keep values vary by level of milk production, days in milk, and how much time the cow is pregnant. In the illustration, conception occurred in the third month after calving, or the cow remained open. When the keep value decreases below $0, it is optimal to replace the cow with a heifer.

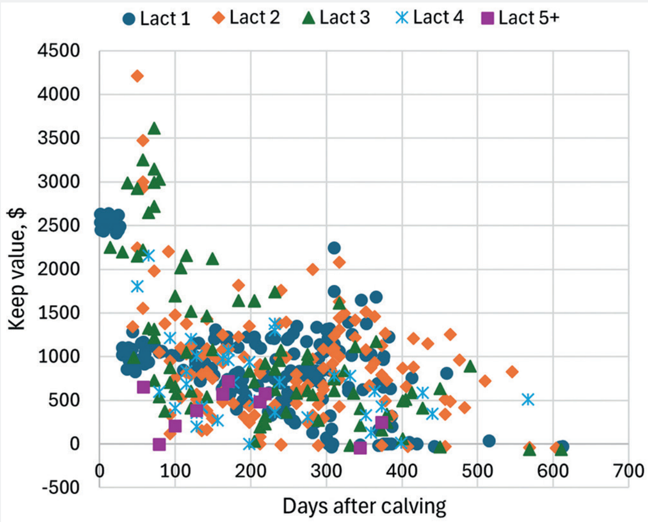
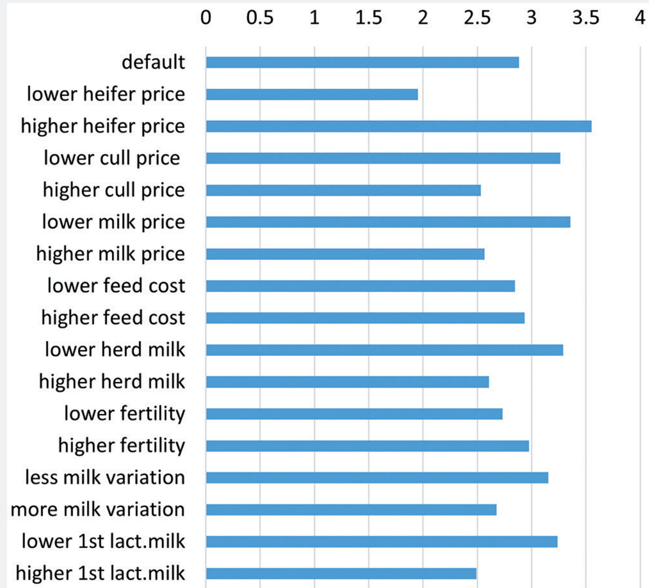


Figure 2: Sensitivity analysis of inputs that affect optimal annual replacement rates in a model with optimal replacement decisions using keep values. The inputs were varied one at a time from the default through multiplication by 0.75 or 1.25.



When the keep values of open cows are compared to daily milk income minus (over) feed cost (IOFC), then typically the IOFC are still several dollars above $0 when the keep value has already decreased below $0. This implies that keeping cows until their IOFC decreases below $0 is too long. The opportunity cost of delayed replacement is approximately $20 per week. An extreme case of this phenomenon is cows that produce milk approximately 80% or less compared to the average cow will never have a positive keep value and should be replaced immediately. In some cases, such cows can still have an IOFC of more than $6 per day. They should be replaced because they are the least profitable cows in the herd and replacement increases the average profitability. As described above, it is difficult to accurately predict future milk yield and therefore future cash flows, however.

Optimal replacement rates

We can mimic a whole herd and apply optimal replacement (and insemination) decisions using keep values. The results of such an optimal replacement policy are theoretical optimal replacement rates. Earlier such studies found optimum annual replacement rates often in the upper 20s to lower 30s percent.[5] Sensitivity analysis have revealed important drivers such as the difference between beef (cull) price and heifer replacement cost. The results in figure 2 are from such a sensitivity analysis. Given many reasonable inputs, the default productive life in this analysis was 2.9 years (34% annual replacement rate). Inputs were then changed one at a time from the default by multiplying the default input by 0.75 (lower or less) or 1.25 (higher or more).

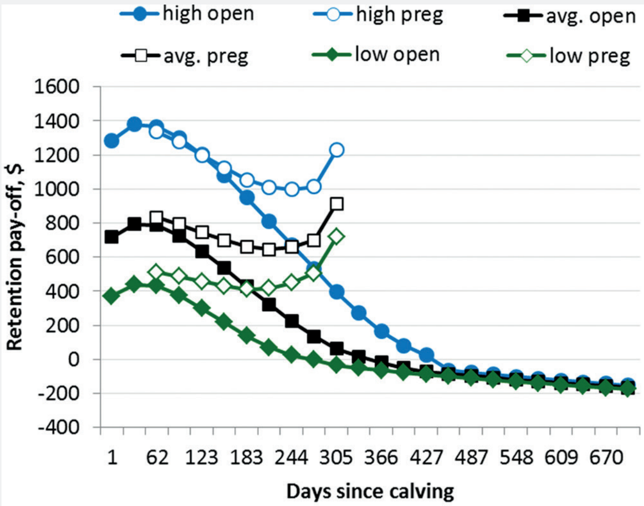
Increased productive life was observed with higher heifer prices, lower cull cow prices, lower milk prices, higher feed cost, lower herd average milk yield, higher fertility, less milk variation, and lower first lactation milk yield. In these cases, the model decided to keep cows longer. The input variable of less milk variation mimics a more uniform herd in terms of milk production within a parity. Within a more uniform herd, there are fewer very low profitable cows that should be replaced soon. The variable of lower first lactation milk yield mimics a greater difference in milk production between first and later parities. Greater income over feed cost reduced herd average productive life because the differences between more profitable and less profitable cows is greater, triggering the replacement of low producing, less profitable, cows.

Practical support of culling decisions

Figure 3 is a practical application of keep values in a real 460-cow dairy herd on a day in August 2024. Cow items like days in milk, parity, milk yield, reproduction status, semen type, genomic Net Merit, etc. were extracted from the farm's dairy management program. Some input herd statistics like average milk yield per parity were calculated from the management program and prices were added by the manager. There were 22 cows with negative keep values ranging from -$1 to -$91 with an average of -$32. Negative keep values imply that a cow should be replaced by a heifer now. Negative keep values are the opportunity cost of keeping a cow in the herd too long. In this case, delayed replacement is assumed to be only for one week. Thus, the keep value is the opportunity cost of replacing these cows one week too late. Much larger negative values are only possible if a cow that should be replaced now, is kept much longer.

The keep values appear to be reasonable, most of the time, when browsing through the cow pages of cows. Many challenges remain for the application of the keep values concept in practice. For example, automatic milk yield recording sometimes failed, which affected the predicted future milk yield. Feed costs were based on estimated dry matter intakes from

Figure 3: Example of keep values in a 460-cow dairy herd. Negative keep values imply that a cow should be replaced by a heifer now. Negative keep values are the opportunity cost of keeping a cow in the herd too long. In this case, delayed replacement is only for one week and therefore negative keep values remain close to $0. Much larger negative keep values are only possible if a cow that should be replaced now is kept much too long.



NASEM,[16] but different rations and their different cost were not considered. Similarly, body weights were estimated by parity, days in milk and pregnancy status only, but not available for individual cows. Disease status and history were not included directly, but were only influential when they caused lower milk production. The value of the pregnancy, and therefore the keep value, was based on semen type (sexed dairy or beef) and genomic Net Merit of the cow, but genomic data were not imported correctly sometimes. Selection biases may have to be reduced. Efforts are underway to overcome these challenges.

Despite remaining challenges, making replacement decisions based on expected future cash flows is a sound concept. Most dairy producers are already trying this, if only intuitively. With more technology and data collection occurring on dairy farms, the accuracy of these future cash flows can be improved. For example, body weight scales or cameras may provide accurate estimates for individual cows where those data are now often not available. Sensors already help predict fertility and health, which could be used to future cash flows estimates. The cash flow concept also applies to other decisions, such as which type of semen and sire to use, when to start and stop insemination cows and when to dry off a cow. Work is currently being done in this area.

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