Profitable Culling and Replacement Strategies

Brian R. Radke, DVM, PhD

Dairy Research & Technology Centre and Beef, Dairy and Sheep Branch, Animal Industry Division, Alberta Agriculture, Food and Rural Development, #905 6909 116 Street, Edmonton, Alberta, Canada T6H 4P2
Email: brian.radke@agric.gov.ab.ca

- **Take Home Message**
  - Culling rates can significantly impact dairy herd profitability.
  - Producers should consider lowering their culling rates by selling replacement heifers.
  - Freshening all heifers may maximize genetic progress and milk production, but it does not maximize profitability.
  - Heifer selection can be based on their genetic indices for milk.

The purpose of this paper and presentation is to encourage dairy producers to critically evaluate their culling and replacement strategies. A strategy many producers should consider is to increase their profit, and lower the herd culling rate, by selling first calf heifers prior to calving. The heifers’ genetic indices can be used to select which will be sold and which will enter the milking herd. However, culling and replacement strategies are complex economic decisions that need to be tailored to individual herd circumstances. This tailoring requires an understanding of the underlying principles of animal replacement, some of which are complex. This paper dispels some of the myths about culling and replacement strategies the dairy industry harbours, for a more extensive discussion see Radke and Lloyd (2000).

- **Myth: Simple examples can elicit optimal culling decisions and strategies.**

Not infrequently, simple examples employing a partial budgeting approach are used in an attempt to illustrate optimal culling decisions. These simple
examples are inadequate because, by calculating a value of the replacement decision in isolation from the other choice that is available, consideration is given to only part of the optimal culling decision and the value that is calculated is wrong. In addition, partial budgets applied to replacement decisions do not use the correct decision rule and, even if all these obstacles were overcome, this approach is appropriate only for culling decisions at the margin (i.e., only for deciding whether one more heifer should enter the herd).

For example, consider the following: if the available heifer replaces a cow, the net return in the first year will be $850 ($400 in net revenue from the sale of milk and the calf from the heifer’s first lactation, plus $450 from sale of the cull cow). This analysis suggests all heifers should be freshened. However, this incorrect analysis misses the point that the choice is between freshening the heifer and selling the cow, or selling the potential replacement and keeping the cow another lactation (assuming no expansion). A similar mistake would be made if only the option of selling the replacement heifer and keeping the cow was considered in isolation. This latter scenario would generate a profit of $2,000 ($1,500 from sale of the replacement heifer plus $500 in milk and calf revenue from the cow). This analysis suggests no heifers should be freshened!

These analyses are intuitively objectionable for a number of reasons. First, any example which results in such extreme suggestions that all or none of the potential heifers should be freshened is questionable. Furthermore, these examples ignore the future implications of the decision of whether or not to freshen the heifer. The impact of the decision on herd genetics has been ignored. These examples also ignore critical information about the animals themselves. The analysis would vary if the cow was in her second lactation versus her fifth. In the latter case, the cow likely faces a higher risk of being culled next lactation, in which case she would then be replaced by a heifer, which due to annual genetic improvement of 1 - 2%, should on average be superior to the replacement available this lactation. This further suggests that under either decision, the analyses need to be extended to consider the future replacements and the future replacements’ potential replacements for an extended time frame. To correctly value the profit from replacing the cow in this lactation or a future lactation, the profit of the heifer and cow and all their future replacements must be calculated and compared.

The partial budget can not address these issues because it is generally not the correct method of analyzing replacement strategies. A discussion of the economic decision rule for analyzing capital assets, such as breeding livestock, will lay the groundwork for understanding why partial budgeting is inappropriate with capital assets. Capital assets, which include cows, are defined as those assets which generate cash flows over multi-period lives. The general decision rule in capital budgeting, customized to culling and simplified by ignoring future replacements, is to replace the current asset (e.g., cow) with a replacement (e.g., heifer) if the heifer’s expected average profit per lactation is greater than
the expected profit from the cow’s next lactation; and also greater than the expected average (time-valued) profits from the cow’s subsequent lactations. So not only did the partial budget approach incorrectly value the profit of the replacement decision, it failed to use the correct decision rule in making the decision.

Capital budgeting is the preferred method of considering the economics of capital assets including their optimal replacement policies. Capital budgeting theory can be operationalized through numerical stochastic dynamic programming to solve such complex problems as the optimal culling rate in a dairy herd. Simulations are useful in determining the effect on herd profit of not following an optimal replacement strategy (Dohoo and Dijkhuizen, 1993; Van Arendonk, 1984). These complex computer programs consider different culling strategies and their future ramifications on herd profit over an extended period of time, often decades.

Models to directly aid producers in assessing how many and which animals to cull are receiving increased attention. Any such decision-making model requires extraordinary predictive power for the future profits of the animals are required. The prediction of future profit requires predicting the future milk production of all the animals in the herd and their potential replacements. At a minimum, to predict future milk production, the future reproductive performance of each individual animal in the herd must be predicted. Updated versions of these predictions are required every time a replacement decision is considered. Furthermore, these predictions are required for the future replacements and the future replacements’ potential replacements for an extended time frame. These predictions are not trivial and place a great burden on any model for aiding replacement decision making.

**Myth: All producers should raise and freshen all their heifers.**

The conclusions that a culling rate of 20% to 30% optimizes producer profit is unanimously supported by optimization (McCullough and DeLorenzo, 1996; Bauer, Mumey and Lohr, 1993; Rogers, Van Arendonk and McDaniel, 1988; Congleton and King, 1985; Van Arendonk and Dijkhuizen, 1985; Killen and Kearney, 1978) and simulation (Allaire, 1981; Allaire and Cunningham, 1980) studies. These studies assumed a constant herd size, no seasonal effects on reproduction and production, and culled cows being sold for meat (not dairy) purposes. Other simulation studies (Congleton, 1988; Kuipers, 1980; Korver and Renkema, 1979; Pearson and Freeman, 1973) which considered subjectively selected culling rates or strategies for comparison, indicated that profit would be increased with culling rates below the approximate average
35% culling rate\(^1\) in the Alberta dairy industry in 1998 (WCDHIS). This is not atypical of culling rates in Canada and the northern states that don’t suffer strong seasonal effects on reproduction and production. In contrast, work by McCullough and DeLorenzo (1996) suggests in the south, where seasonality plays a greater role in production and reproduction, a culling rate in the 40% range may maximize profit.

In Alberta, for example, the average producer is annually freshening roughly 35 heifers for every 100 cows. The literature strongly suggests less than 30 heifers should be freshened for every 100 cows, assuming constant herd size. In other words, not all heifers should be freshened. The unanimous results of these multiple studies are compelling because, not only did the various models employ different assumptions and analytical techniques, but as well, the models operated under economic conditions representative of a number of countries (i.e., Canada, Netherlands, U.S.A, England, Ireland).

Given that the excessive state or provincial culling rates cited are only averages, a significant portion of herds have culling rates greater than the average. If the distribution of culling rates is symmetrical, then likely 60% or 70% of the herds are culling at a rate greater than that which maximizes profit. As will be discussed further under the Myth about expansion, when the expansion trend is considered, an even higher percentage of herds likely have an excessive culling rate because during expansion the optimal culling rate often decreases.

**Myth: A culling rate is a culling rate is a culling rate.**

In contrast to the 35% culling rate reported above for Alberta, if you consult a Michigan DHI report for 1996, a culling rate of 27% is reported. So for every 100 cows (milking and dry), 27 were culled, right? Not necessarily! In fact, it is 37. Another clue that the culling rate is not as it may appear on the DHI report is the realization that greater than 27% of the herd, often 40 to 50% of the herd, is first calf heifers. If the percentage of first calf heifers in the herd is constant, the herd culling rate is at least as great as this percentage corrected for the calving interval of first lactation heifers.

Intuitively, most people believe the culling rate is equal to number culled per year/average herd size. Alternatively, the culling rate may be calculated as number culled per year/(average herd size + number culled) (Ferris, 1987). For the remainder of this article the first definition will be used, not only for its intuitive appeal, but as well, assuming the herd operates at capacity, epidemiologically this is the correct definition because the denominator

\(^1\) Culling rate, annually defined as, the number of animals leaving the herd due to sale or death divided by the average herd size.
represents the animals at risk of being culled. I refer to the second definition as the herd turnover rate. Mistaking the herd turnover rate for the culling rate has resulted in the errant conclusion that the industry culling rates are optimal.

- **Myth: An excessive culling rate has minimal effect on profitability.**

The simulation models cited earlier revealed the increased profit associated with use of the optimal culling rates varied from 2% to 40%. So potentially, the strategy of an optimal culling rate could be quite profitable to dairy producers. The large range in increased profit is not surprising for the simulation models assumed a level of herd management and then compared some arbitrary method of culling with an optimal culling strategy. So the range in profit will vary with how “good” the arbitrary method of culling was relative to the optimal culling for the given level of herd management.

- **Myth: High culling rate strategies maximize milk production, maximize genetic progress, and therefore, maximize profit.**

The simulation studies did reveal that the excessive average culling rates commonly seen in the dairy industry maximized milk production, and genetic improvement but did not maximize producer profit. The studies that considered the optimum culling rate suggest that at higher culling rates the cost of attaining the higher milk production and genetic improvement is greater than their value. Closer examination of these costs and benefits reveals the complex economic nature of culling decisions in a herd. A large portion of the cost is the expense of identifying the lower producing, and therefore less profitable, first lactation animals. Applying the method of before and after comparison we can quantify this expense (notice here this approach is used to quantify the results of a decision, it is not being used to make the decision – see Radke and Lloyd (2000) for a more detailed discussion of this point). Assume that prior to knowing her productive capability the heifer is worth $1,500 and after determining she is a poor producer she is worth $700 ($300 in net revenue from milk sales and $400 from her sale for beef). So $800 has been paid to identify each of the poor producers. The literature indicates the economic benefit of increased rate of genetic improvement and increase in milk production from higher selection pressure is simply not sufficient to make up for this $800 loss on each of the first lactation culls. Of course this is a oversimplified explanation because, as suggested in the first Myth, to understand the economics of culling strategies the effects on the herd and the resulting future herd, rather than single animals, must be considered.
The scientific literature suggests that there is more profit associated with culling at less than the biological maximum (i.e., not freshening all available heifers), and selling the excess heifers. The drop in milk production due to decreased selection will be somewhat compensated by increasing the average age of the herd and having more cows in the higher producing later lactations. The strategy of generating revenue from the sale of excess heifers with the concomitant decrease in cull cow sales and increased average age of the herd will be more profitable than a younger herd of higher producing animals generated by a higher culling rate.

The optimum culling rates are highly dependent on the price of a springing heifer relative to the price of a cull animal. As the difference between these two prices narrows the optimal culling rate rises. So if, for example, springing heifers are worth $1,500 and they can be milked and the culls sold to another herd for $1,500, the optimal strategy would be to freshen all heifers, as in essence the information identifying the best producing heifers is being attained for free.

It must be recalled that presumably you desire to maximize profit not milk production. With everything else the same, higher producing animals are generally more profitable. So for a given culling rate, the highest producing animals are desirable, but the strategy of higher milk production at any cost is not economically wise.

**Myth: The herd culling rate is an active decision and not dictated by heifer pressure.**

For many producers and their advisors the herd culling rate decision is a passive one, largely driven by heifer availability. Some suggest their decision is an active one as evidenced by the annual variability in their culling rate. But rather one must ask, “When was the last time this actively assessed culling rate didn’t exactly equal the number of available heifers and as a result heifers were sold or purchased?” Furthermore, if heifers were sold or purchased was this the result of an active decision at the herd level with regards to the culling rate or was it the result of decisions regarding only the individual heifers?

**Myth: I can’t reduce my culling rate as the majority of my culls are involuntary.**

First we must resolve the definition of an involuntary cull. Voluntary culls have traditionally included those animals that leave the herd due to low milk production in the absence of disease, or those sold into other producers’ herd. This then nonsensically implies all diseased animals which have left the herd
and not entered another herd are involuntary culls. Involuntary culling has traditionally been loosely defined as “those cows that leave the herd against the wishes of the producer”. This is in keeping with “not done of one’s own free will, not done by choice” which is Webster’s (Neufeldt, 1994) first definition for involuntary. Based on these definitions two culling reasons can be considered involuntary: sudden unexpected death and sterility. Culling is solely an economic decision. To recognize this consider the following question: given a third lactation cow rated excellent in conformation, with a 800 total BCA would you cull her for reason X, where reason X is any problem for which one may consider culling. If she has mastitis or infertility, commonly cited reasons for involuntary culling, and yet you would not sell her, then by definition it can not be an involuntary cull.

The influence of this concept of involuntary culls has also extended to the creation of rules of thumb that suggest commonly 20% of the herd is involuntarily culled with an additional 10 to 15% culled for voluntary purposes. However, there is no literature which supports these rules. In fact, some of the culling studies (Dohoo and Dijkhuizen, 1993; Rogers, Van Arendonk and McDaniel, 1988) suggest these rules of thumb for involuntary culling are wrong, culling animals that should not have been.

Webster’s second definition of involuntary is “not consciously controlled, automatic (e.g., sneezing)”. This is likely more appropriate with regards to the concept of involuntary culls. The recognition that culling is fundamentally an economic issue has been proposed (Fetrow, 1987). However, this distinction purely for the purpose of semantics serves little purpose. The distinction is important if the involuntary/voluntary culling paradigm is resulting in “not consciously controlled” culling decisions. If producers and their advisors continue to believe they have no choice in many of their culling decisions, their opportunity to change these decisions and their culling rates is severely inhibited. Stressing their economic nature may be a method to encourage the dairy industry to critically evaluate culling decisions. Producers must focus on culling the least profitable animals and not worry about classifying the culled animals into the arbitrary and meaningless categories of voluntary and involuntary culls.

This is not to say that classifying culls by reason has no purpose. Monitoring culls by reason, rather than the “voluntary” nature of the decision, is much more effective at identifying potential herd health issues. These identified areas of herd health (e.g., lameness, mastitis, etc.) are potential sources of improved animal and herd profitability if they can be managed in a cost effective manner.

The concept of the voluntary nature of the removals has no place in either culling and replacement strategies, or herd health monitoring.
- **Myth: The cow herd is in such a poor state that it is most profitable to freshen all the heifers.**

While in the short-term this statement may be correct, in the long run this is a poor strategy as the poor survivability of the cows impairs herd profitability. Again, in assessing the optimal culling rate the expected profitability of the heifers must be compared to the current cows. The expected profitability of an animal is largely a function of her milk production ability, which is a function of her reproductive capability. If cows have severely impaired production or reproduction their future profitability may be so low that, as a stopgap measure, it may be more profitable to freshen all heifers. However, this is only a short-term remedy, and the underlying cow problems need to be addressed.

- **Myth: The optimal culling rates don’t apply to herds undergoing expansion.**

Actually, this statement is true, at least for internally expanding herds. The optimal culling rate for a herd undergoing internal expansion should be less than the same herd maintaining a constant herd size. The approach to culling in the face of expansion is no different than the approach with a stable herd size – as discussed under the first Myth, all options and their associated ramifications must be considered. The underlying principle remains to replace a cow only if there is an animal available which will be more profitable. If the facilities are not at capacity, while a cow may be “replaced” with a heifer, the cow could also have remained in the herd in addition to the new heifer. If the cow is culled her future returns are foregone. So the cow should be sold only if she is losing money. Any animal that is at least covering her variable costs and making some contribution to the fixed costs would be kept, resulting in a lower culling rate until the facilities are at capacity at which time the culling rate would rise.

Care is required in comparing the culling rate of herds undergoing expansion with the literature’s optimal culling rates which are for herds of constant size. The mere act of expansion can result in a lower culling rate than if the herd had maintained a constant size. For example, suppose a 100 cow herd internally expanded to 110 cows in one year and during this year the herd had a 37% culling rate. To achieve a 37% culling rate the herd must have sold 39 cows (0.37 x (100 + 110)/2). So 39 heifers must have entered the herd just to maintain a herd size of 100 cows. In addition, 10 more heifers must have entered the herd to permit the internal expansion from 100 to 110 cows. So the herd of 100 cows actuallyfreshened 49 heifers. If the herd had not expanded, its culling rate would have been 49%! Similarly, one would expect that once the herd stops internal expansion the culling rate should return to 49%. In contrast, if prior to internally expanding the herd had targeted a 30% culling rate to
maximize profit, upon expanding the herd’s culling rate would drop to 19% (20/105 x 100%). That is, 30 replacement heifers would have joined the herd of 100 cows and in order to achieve the desired herd size of 110, 20 of the 130 animals would have been culled.

**Myth: Optimal culling rates vary with the level of herd milk production.**

The optimal culling rate results from comparing the profit of the potential heifer replacement against the cows currently in the herd. So any factors that affect the profitability of both the heifer, as well as the cow, has minimal impact on the optimal culling rate. This result was unanimously borne out in the optimization studies (McCullough and DeLorenzo, 1996; Bauer, Mumey and Lohr, 1993; Rogers, Van Arendonk and McDaniel, 1988; Van Arendonk and Dijkhuizen, 1985; Killen and Kearney, 1978) which concluded that factors such as the level of milk production, price of milk or price of feed had minimal effect on the optimal culling rates.

**Myth: Genetics aren’t useful in a heifer selection strategy.**

As explained earlier, if the culling rate is reduced, then fewer heifers are required to enter the herd necessitating a method of heifer selection. Evidence exists that producers are not using genetics in their culling decisions (Radke et al., 2000). This may be a function of the fact that heifers’ parents’ PTAs explain less than 7% of the within herd variation in first lactation mature equivalent milk production (Radke, 1998).

While genetic estimates don’t explain a lot of the within herd variation in first lactation milk production, they are somewhat able to correctly rank animals, within herd, on subsequent production. Because it is the ability to rank animals on milk production rather than predict actual milk production that is important in a heifer selection rule, genetics are valuable in heifer selection. Recent research by Radke et al. (1999) on the optimal use of genetics in heifer selection suggested that by basing heifer selection on genetics producer profit increased by over $20 per heifer versus random heifer selection. This $20 increase in profit accrues over the heifer’s lifetime. The study also revealed that heifer selection based on genetic estimates captured only about 25% of the profit available if the animals could be correctly ranked on their subsequent milk production and profitability.
Myth: Heifer selection is a complicated strategy.

Heifer selection is a relatively simple matter. Based on the desired culling rate among the cows, the number of excess heifers is known. Heifers which are expected to calve within a given time period should be separated into cohorts for selection purposes. An enterprise budget is used to determine the period in which it would be most profitable or least costly to sell the excess heifers. Based on their genetic indices for milk for that period, the heifers which serve as a cohort for selection purposes are then ranked, with the lowest ranking requisite number of heifers being sold.

The heifer enterprise budget is used to determine when heifer selection should occur and logically should be broken down into periods that coincide with the release of new genetic estimates. Care must be taken in creation of the enterprise budget to only consider costs that would change in response to raising fewer heifers. For example, consider a farm that currently has heifer facilities. If, in response to raising fewer heifers, the profitability of the remaining heifers will not increase, say due to less overcrowding, or if no other animals will take the place of the sold heifers, the facility cost cannot be assigned to any other animals and will be incurred regardless of whether the heifers are sold or not. As a result, in this case, the cost of the facilities should not be included in the cost to raise a heifer.

Myth: Heifer selection is a risky strategy.

While freshening fewer heifers and therefore having fewer animals available entails some risk in terms of your ability to respond to unforeseen circumstances including low production of the selected animals, heifer selection also has favorable risk attributes. Firstly, selection with sale of the excess heifers offers an immediate large source of cash flow from their sale revenue. Secondly, this management strategy is favorable in terms of its short and long-term reversibility. In the short-term if you decide you have sold too many heifers and want to freshen more heifers than are available, more can be bought although this may present a biosecurity risk. Longer-term, if heifer selection is practiced and you are unhappy with the results you could simply revert to the old practice of freshening all future heifers. Health management, by providing a consistent environment which permits the expression of animals’ genetic potential, plays a critical role in minimizing the risk from heifer selection.

The above myths will challenge many of your assumptions and beliefs about culling and replacement strategies. Certainly it is the role of management teams to customize these strategies to their particular herd situation. Understanding the rationale behind any management strategy is important in ensuring the strategy is correctly applied to your current operating environment.
A good place to start with regard to critically evaluating your herd’s current culling and replacement strategies is to answer the following three questions:

“What is your herd’s culling rate?”

“Why?”

“Have you considered selling replacement heifers?”

**References**


