

Invited Review: Culling: Nomenclature, Definitions, and Recommendations

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ABSTRACT

Replacing cows on a dairy is a major cost of operation. There is a need for the industry to adopt a more standardized approach to reporting the rate at which cows exit from the dairy, and to reporting the reasons why cows are replaced and their destination as they exit the dairy. Herd turnover rate is recommended as the preferred term for characterizing the cows exiting a dairy, in preference to herd replacement rate, culling rate, or percent exiting, all of which have served as synonyms. Herd turnover rate should be calculated as the number of cows that exit in a defined period divided by the animal time at risk for the population being characterized. The terms voluntary and involuntary culling suffer from problems of definition and their use should be discouraged. Destination should be recorded for all cows that exit the dairy and opportunities to record one or more reasons for exiting should be provided by management systems. Comparing reported reasons between dairies requires considerable caution because of differences in case definitions and recording methods. Relying upon culling records to monitor disease has been and will always be an ineffective management strategy. Dairies are encouraged to record and monitor disease events and reproductive performance and use this information as the basis for management efforts aimed at reducing the need to replace cows.

Key words: dairy, culling, turnover rate

INTRODUCTION

In advance of the American Dairy Science Association's DISCOVER Conference on "Reducing Culling Rates in Dairy Herds: Creating an Environment for Success" in October 2004, a subcommittee was formed for the purpose of reviewing terms currently in use on dairy farms relating to culling. There was a general feeling that there were too many terms in use for the

same trait, and even that the same terms were sometimes defined differently. This paper is the product of the committee's initial effort along with revisions based on input received from those that attended the conference. In addition to the original charge, the committee chose to add some observations on the general topic of culling in dairy cattle and on appropriate ways to examine the underlying factors surrounding the exit of dairy cows. The committee hopes that this paper will stimulate more thought and encourage the dairy industry to standardize the use of culling terminology, and discontinue the use of other terms. Further, we hope that this discussion will contribute to a wider reexamination of long-held dogma regarding culling in dairy cows.

SIMPLE DEFINITIONS

Culling

Culling (exiting) is the departure of cows from the herd because of sale, slaughter, salvage, or death. In most cases the cow that exits is replaced; thus "replacement" has been a useful synonym for the event. The term "cull" refers to all cows that leave the dairy regardless of their destination or condition at departure. Some may object to including cows that are sold for dairy purposes as part of a general cull category, as the word "cull" generally means to separate off for undesirable reasons. This single nomenclature may cause problems of interpretation for dairies that market adult cows for breeding or milk production, and confound the use of industry benchmarks regarding the number of animals that exit compared with dairies that do not market adults. Nevertheless, a general term is needed, and cull remains the term in wide use in the industry.

The least ambiguous classification of cows removed from herds is based on the destination of the cows after removal and these can be placed into 3 groups:

Dairy Sale. Sale in the context of culling means that the cow was sold alive to another dairy, with the expressed goal of continuing to provide income, such as producing milk, calves, or embryos.

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Slaughter - Salvage. Slaughter means that the cow left the dairy alive to be slaughtered for human consumption. This would be the most common destination for culled cows; it includes cows destined for slaughter through general slaughter markets, sale barns to packing plants, butcher shops, or on-farm use for family or employee consumption. Salvage refers to those animals that leave the dairy alive but are not intended for human consumption; that is, cows rendered or used for purposes other than human food. Such cows may have received antibiotics or other drugs and were in the withholding period when removed, been culled shortly after major surgery, or been culled with diseases that exclude them from human consumption (e.g., neurological conditions, peritonitis, pleuritis, or cancers). Those 2 categories, slaughter and salvage, are merged for practical reporting because often the final destination is not known at the time the cow exits the dairy. Some cows sent to auction for slaughter end up milking in other dairies, but these can be coded as going for “slaughter” because that was the intention when they left the dairy.

Death. Death (died, dead) means that the cow died on the dairy. The newly implemented FDA (2004) rules specifically forbid any part of a nonambulatory cow from entering the human food chain. Coupled with the strong recommendation that nonambulatory cows should not be transported for humane reasons (American Veterinary Medical Association, 2005), downer cows that cannot be successfully treated should be euthanized on the dairy for on-farm disposal or for rendering. Downer cows euthanized on the dairy should be included in the “died” category. This change in FDA rules will mean that more cows will be reported as died than in the past.

Coding for Culling Events

Currently, most culling record systems characterize removals using a mixture of destination and reason for removal (e.g., dairy sale, mastitis, reproduction, death). The mixture of destination and removal reason confounds efforts to quantify risk areas in individual herds. For example, cows may leave a dairy to different destinations but often for the same underlying reason—some die on the farm of mastitis, whereas others are sold to slaughter because of chronic mastitis. A 2-tiered coding system for cow removals of destination first, followed by reasons for removal to any destination second, could make the culling information less ambiguous and more valuable.

Recommendation. The 3 mutually exclusive destinations of cows removed from herds are dairy sale, slaughter (including salvage), and death. Dairy records

system designers should be encouraged to adopt these 3 destination codes as standard terms in their systems.

DEFINING THE MAGNITUDE OF CULLING ON A DAIRY

Quantifying the amount of culling on dairies is highly beneficial in the comparison of herds. From an epidemiologic perspective, culling is a specific event (an incident) in a cow's life on the dairy. Measuring the occurrence of incidents is usually done by measuring the rate (incidence) of the events over a specified period in an at-risk population. A simple count of how many cows were culled last year may be useful to a specific dairy. However, if the magnitude of culling is to be compared between dairies, then some standardization (i.e., percentage of the at-risk population) is needed to account for the difference in herd size, and any calculation should specify a fixed time (e.g., 1 yr).

Culling Incidence Rate

From an epidemiologic point of view, the ideal measure of the amount of culling is a culling incidence rate (Dohoo et al., 2003):

Number culled over a specified time period ÷ population at risk for being culled over the same period.

The number culled is straightforward: simply count those cows that exited within the relevant period. The specified period is typically a year for culling but could be per lactation, per month, or per some other period of interest (e.g., the first 60 d of lactation). The population at risk is often the source of confusion in culling discussions.

One way in which the at-risk population can be determined is by following a predefined cohort of cows over time until all have been culled. A cohort is a group of individuals with some common characteristic when they are assembled or designated and which are then monitored for some period. For each cow, the years of herd life (from start to cull) would be determined, and the years across all cows summed, thereby producing the cow-years at risk. The resulting culling incidence rate would define the risk (per cow per year) of being culled. These calculations are often used in epidemiological or clinical trials.

A second way of determining the at-risk population is to follow all cows on a dairy for a year, and count the number in that cohort that was culled. Like all prospective cohort studies, consideration must be given as to whether the starting cohort (e.g., all cows in the

herd on July 1) is representative of the general population or demographic of interest.

Unfortunately, practical problems occur for either of those 2 methods of calculating the magnitude of culling on an operating dairy. For the first technique, cohorts of cows generally do not arrive together. Although simultaneous arrival is not strictly required for determining cow-time at risk, it makes it easier. If all cows in the dairy on a given day determine the cohort, then that day's particular demographics (considering parity, lactation stage, season, etc.) will tend to influence the observed culling incidence rate and thus reduce the comparability to other herds. Management factors operating for a short time could also influence the outcome of the cohort as well, but not reflect the general state of the dairy. In each successive month, fewer of the original cohort remain, and those are usually mingled with the herd replacements. Culling incidence rate is a valuable research tool to use regarding culling, but tracking the cohort and collecting the data take a long time so it is often too historic to be useful in addressing current managerial needs. Still, it provides some valuable clues as to problems on a population basis that are less likely to change quickly over time.

Herd Turnover Rate

The literature and current computer records systems use a number of terms to describe culling. Terms like "yearly turnover" and "cows leave, %" (AgSource Cooperative Service, 2005), "culling rate" (e.g., Hoekema, 1999a,b; Brett, 2003), "proportion removed from herd" (Smith et al., 2000), "percent left herd" (Gangwer et al., 1993), and "replacement rate" (Allaire, 1981) are used to describe the extent of culling. Calculations of those indices vary not only between indices but also for the same index (e.g., culling rate in Hoekema, 1999a,b vs. Brett, 2003). Currently, the reader or user must be wary when interpreting values or comparing them to those from other dairies or research studies (Radke and Shook, 2001).

Again, the numerator for those calculations is straightforward, although some have excluded dead cows, which is a mistake if overall turnover is being considered. Unfortunately, 2 different denominators are used as well. Some use the mean number of cows (parity 1 or older) on the dairy for the year. A simple approach is to use the average of the starting and ending inventory. If herd size is relatively stable, the result is a fair approximation of the number of cow-years at risk, even though the cows represented in the starting cohort are not all the same as in the ending cohort. If calving patterns throughout the year are consistent, then the parity distribution of the population is also

reasonably represented. A more precise approach is to average the cow inventory at monthly intervals over the year (e.g., DRMS, 1997). The monthly mean accounts for changes in population size across the year and comes closer to actual cow-years in the herd. Computers make it possible to calculate cow-years, cow-months, or even cow-days in the herd, and the latter is the ideal.

Turnover rate is a traditional term used in business inventory monitoring (Bureau of Labor Statistics, 2004) and including "herd" reflects that the number is based on herd performance. Turnover rate, unlike culling rate, avoids the negative connotations of "cull" for cows that leave for dairy purposes. Herd replacement rate is also a synonym that is more neutral than culling rate. Herd turnover rate should be defined as

number culled over a specified time (e.g., year)/
mean cow inventory for same time period (or,
if available, cow-years at risk).

This ratio $\times 100$ produces a familiar measure of the magnitude of culling from a dairy expressed as herd turnover rate (%), but it has also been called cull rate, culling rate, percent exiting, or proportion leaving.

An alternative denominator described by various authors and in use in some records systems ("percent cull rate," Minnesota DHIA, 2000; "herd turnover rate," Radke and Shook, 2001) is calculated by adding the number culled to the current or mean herd inventory. The calculation of herd turnover or culling rate by this method has been

number culled over a specified time (e.g., year)/
mean cow inventory for same time period +
number culled during period.

This calculation is misleading and should not be used to describe culling. The apparent justification for adding the number culled to the denominator is the desire to have all cows at risk at some time during the year included. However, all of the cows represented in that denominator were not all at risk for the defined period of interest (e.g., the entire year). Often, each culled cow was replaced at some time thereafter by another cow. Considering both the cow culled and her replacement across the year, the farm had but 1 cow in the herd for most of the year, which would result in a maximum of 1 cow-year at risk, not 2 as assumed if summing the culled cow and her replacement. The sum of the mean inventory plus the cows culled overestimates the animal time at risk. To illustrate this point further with an extreme example, consider a herd that has only a single cow that milks for 11.99 mo, is then culled, and

Table 1. An example of 2 approaches¹ for calculating herd turnover rate in a stable and an expanding herd, each with moderate or intense culling

Month	Moderate replacement				Intense replacement			
	Stable herd		Expanding herd		Stable herd		Expanding herd	
	Inventory	Culls	Inventory	Culls	Inventory	Culls	Inventory	Culls
	Cows (no.)							
1	100	3	100	3	100	4	100	3
2	105	2	108	2	105	5	108	3
3	110	4	112	4	110	3	112	3
4	103	3	118	3	103	4	118	4
5	95	3	123	3	95	2	123	6
6	93	2	127	4	93	4	127	5
7	95	4	136	3	95	5	136	4
8	100	3	141	4	100	3	141	6
9	97	3	148	5	97	4	148	5
10	96	2	154	5	96	2	154	7
11	101	1	157	4	101	4	157	7
12	105	4	160	5	105	6	160	8
All months	100	34	132	45	100	46	132	61
	Herd turnover rate (%)							
Preferred approach		34		34		46		46
Alternative approach		25		25		32		32

¹Preferred: $100 \times (\text{number culled}/\text{mean population})$; alternative: $100 \times [\text{number culled}/(\text{mean population} + \text{number culled})]$.

replaced immediately by a newly calved heifer. Using the preferred definition, the herd turnover rate is 100%. Using the alternative definition, the turnover rate is only 50%. The preferred calculation reflected the herd's reality whereas the alternative definition severely underestimated the risk of culling during the year.

Table 1 illustrates the calculation of herd turnover rate by both approaches for 4 combinations of herds: stable or expanding herds with moderate or intense culling. The alternative calculation (adding the number culled into the denominator) substantially underestimated the risk of culling in herds. The preferred calculation accurately estimates the risk of culling, even in rapidly expanding herds, as long as the mean cow inventory (denominator) was calculated on at least a monthly basis.

Recommendation. The term "herd turnover rate" is recommended as the term to represent the magnitude of removals from a herd. It is likely that some of the other terms will remain in use. Nevertheless, if all of these various terms in use (herd turnover rate, herd replacement rate, culling rate, percent exiting, etc.) were derived in the same manner—by the preferred calculation—much of the confusion surrounding culling would be eliminated so that producers and consultants could resolve herd management challenges more effectively.

Subsets of Herd Turnover Rate

In the analysis of culling history on dairies, considering the turnover rates in subsets of the total population

is often useful; for example, for first-lactation cows, animals with a particular health event, animals calving in July, cows in the first 60 d of lactation. The preferred calculation of herd turnover rate works the same for a subset of cows. However, such calculations may lead to extreme variability when the population being considered is small; for example, the number of cows that suffer dystocia in a 100-cow herd might be ≤ 5 . Any generalizations about causes or outcomes in such a small starting population are suspect at best.

At the farm level, describing subgroups as turnover rates of the herd is preferable to describing them as a percentage of removed cows. Consider the following statement: 20% of the culled cows died on the farm. With the wide range in herd turnover rates from dairy to dairy, the statement can reflect very different situations. If the herd turnover rate were 25%, the turnover rate from on-farm deaths would be 5% of the herd. However, if the herd turnover rate were 50%, turnover from on-farm deaths would be 10% of the herd.

For some subsets, the process should be more like an epidemiologic cohort study. To consider the turnover rates of cows that suffered dystocia, start with all cows with dystocia and follow them to a specified end-point (probably for a year or a lactation). The resulting rate would be expressed as turnover rate during the year (lactation) following dystocia.

When considering turnover rates for less than full lactations, one should remember that the risk of culling is not consistent across all stages of lactation. Cows experience the highest risk shortly after calving; then

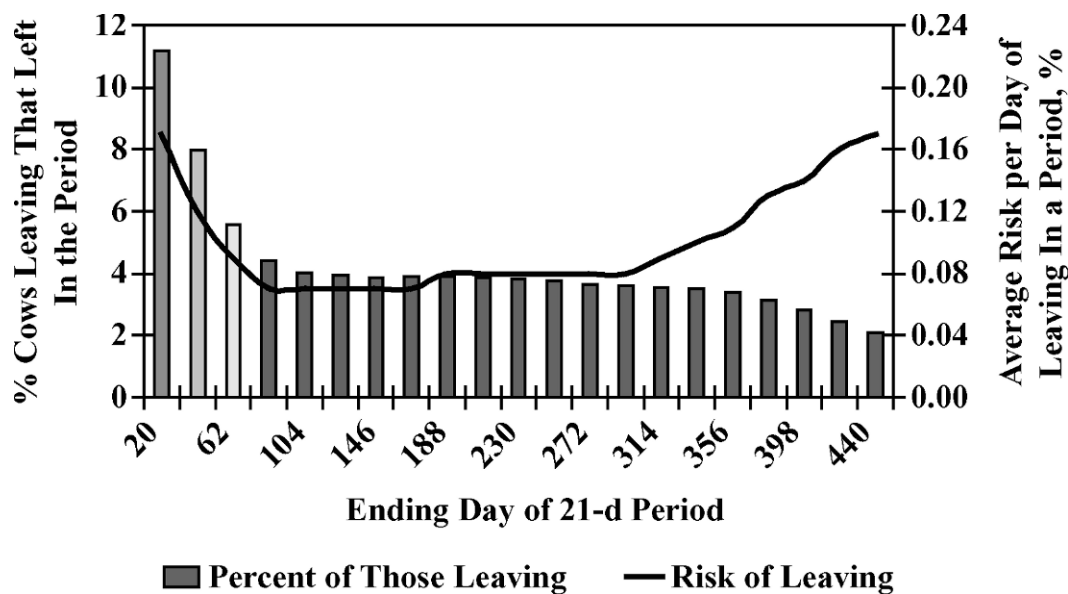


Figure 1. When cows leave the herd and risk of leaving the herd (MN DHIA data, October 1996–October 2001). © MWPS (Midwest Plan Service), Iowa State University, Ames, IA, www.mwpsdq.org. Used with permission: *4-State Applied Nutrition and Management Conference. MWPS-4SD16*.

the risk drops and finally increases again toward the later stages of lactation (Godden et al., 2003; Figure 1). This pattern tends to even out if calculations are done for a herd of stable size across a year, because all seasonal and lactation-stage effects are included over that time and are probably representative of the dairy's general culling-risk profile. Often seasonally grazed herds have different calving and culling patterns than traditional herds, so comparisons with other herds for part of the year should be done with caution.

Recommendation. Turnover rates can be derived for subgroups of the herd in the same manner as for the entire herd, but caution should be taken if cohort size is small. If subgroups of culled cows are discussed, their culling incidence should be described as a subgroup turnover rate rather than as a percentage of culled cows.

REASONS FOR CULLING

Besides culling magnitude, the issue of culling reasons stirs the most controversy relating to culling.

Voluntary vs. Involuntary; Economic vs. Biological (or Forced) Culling

Traditionally, culling has been referred to as either voluntary or involuntary. Voluntary culls were those cows sold for dairy purposes or deemed normal except

that they were poor producers. Involuntary culls were those culled by coercion due to mastitis, extreme lameness, poor reproduction, disease, death, and so on. Despite long-time criticisms leveled at this classification (Fetrow, 1987; Dohoo and Dijkhuizen, 1993; Leslie, 1994; Radke and Lloyd, 2000; Radke and Shook, 2001), these labels have persisted, even though they do not reflect the reality of culling decisions or the characteristics of why cows are culled. Although sales of healthy, productive cows to other dairies certainly occur (6% of all culls in 2002; National Animal Health Monitoring System, 2002), few cows exit the dairy as a low producer if they are pregnant and have a disease-free, mastitis-free, and trauma-free history. A few cows culled as "open" are hopelessly infertile, but in most cases a voluntary, economically based decision was made that the cow was no longer worth breeding compared with replacing her with a heifer.

An alternative conceptual distinction for culls has been to distinguish those that exit because of biological or "forced" reasons from those exiting for "economic" reasons (Fetrow, 1987). Forced culls are those cows for which no possible productive future exists; for example, hit by lightning, permanently sterile, irreparably injured, positive for tuberculosis, etc. Those cows are a small minority of all culls on most dairies. Economic culls are those cows for which a decision has been made that replacing them with another cow is a smart economic option for the dairy. These distinctions are help-

ful for culling discussions because they underscore the reality that culling is primarily an economic decision-making process.

Recommendation. The distinction between the 2 categories, voluntary and involuntary culling, has not been useful for management purposes, and should be discontinued.

Characterizing Specific Reasons for Culling

Dairy records systems have long offered the opportunity for dairy producers to designate why a cow exited the herd. The producer is usually limited to 1 or 2 choices from a list of reasons that often includes dairy sale, low production, reproduction, udder conformation, feet and legs, mastitis, disease, injury, died, and many other miscellaneous reasons.

The process of categorizing culls with a single reason for disposal is subject to many biases and errors. Sometimes the reason is clear and proximate to the culling event (hit by skid-loader and euthanized), but often there are several reasons, and often they are distant and less evident. Consider a cow that was poorly managed in the transition from dry to milking status, developed ketosis and a displaced abomasum, developed a chronic mastitis infection, was transitioned to a high-starch diet too rapidly, developed subacute rumen acidosis and laminitis, was slow to return to estrus, hesitant to stand to be mounted, was never bred successfully, and finally culled 14 mo after calving as an open cow with poor production, high SCC, lame, and in poor body condition. What would the producer assign as the single reason the cow was culled?

The shortcomings of a "single reason for culling" system are confirmed in a study of a small number of New England dairy farms in which the producer was allowed to provide up to 3 reasons for culling (Bascom and Young, 1998). Given the opportunity, producers gave 2 reasons for 35% of culling cases and 3 reasons for 11%. Farmers also have been shown to alter their culling criteria and decision making based on sociological variables (demographic characteristics, attitudes, education, degree of involvement in dairy groups) in addition to economic or biological ones (Beaudeau et al., 1996).

Despite the coding issues, several problems affect the risk of a cow being culled. In a multistate study of herds selected to statistically represent the US dairy industry, the National Animal Health Monitoring System (2002) classified the reasons for culling into 7 categories, not including death on the dairy. Udder or mastitis problems was the leading reason (27%) given for culling and was followed by reproductive problems (26%), lameness or injury (16%), poor production not related to other reasons (19%), disease (6%), and ag-

gressiveness (1%); 4% of cows were culled for other unspecified reasons. Studies and reviews (Fetrow, 1987; Milian-Suazo et al., 1988; Beaudeau et al., 1996; Gröhn et al., 1998; Smith et al., 2000) have described those types of patterns and attributed the increased risk of culling to cows suffering from particular diseases or disorders.

If managers record and track disease reasons for culling, presumably they do so to guide future management decisions aimed at avoiding problems that lead to undesirable culling outcomes. In addition, outside consultants may refer to those data or tabulations to better understand long-standing breakdowns in management. Pointing to prevailing reasons for culling may highlight long-ignored problem areas and motivate change for the better. The data may also be useful input for rough assessments of the costs of disease or for recommendations of control efforts. For those reasons, use by the herd manager justifies the small effort it takes to record the general reasons for culling cows in a comprehensive dairy records system.

Recommendation. Dairy records systems should categorize removals by destination first (dairy sale, slaughter/salvage, or death) and allow selection of multiple predefined specific reasons to help characterize the removal of individual cows. Comparing reasons between herds requires considerable caution because of inconsistency among producers' definition and reporting, as well as the lag between causal and culling events; therefore, any such comparisons should be done with considerable caution and some skepticism.

Inappropriate Use of Removal Reasons

Sometimes dairy managers attempt to use culling reasons to monitor the incidence of disease on the dairy. Those efforts can be seriously misguided because much of the incidence and loss from disease occurs at the subclinical or clinical levels and often these do not result in death or removal; therefore, monitors of culling may reveal only a small portion of a large problem. Generally, the time to direct attention to the disease is months before the cull event occurs. If dairy managers wish to monitor diseases, it should be done in a direct and timely fashion recording clinical disease events and using subclinical disease screening programs.

Recording Diseases

The issue of monitoring disease on dairies becomes immediately relevant when management asks about systems to avoid culling. By monitoring disease rates on a continuing basis, management breakdowns and deficiencies can be identified much earlier and interven-

tions made. Use of this system should save more cows from facing forced culling.

Defining what constitutes a "case" of a disease can be somewhat subjective (e.g., ketosis); suggested definitions are available in the literature (Kelton et al., 1998). A second issue is what constitutes a new case of a disease (e.g., clinical mastitis or lameness) in a cow that has already had a case earlier in the current lactation. Kelton et al. (1998) recommended that clinical cases that occur more than 30 d after the first case should be counted as a new case. That recommendation presumes that clinical manifestations within a month of the first appearance of a clinical problem are a continuation of the original problem. For many diseases, the recommendation is that only one case be recorded per lactation (e.g., dystocia, milk fever). That recommendation avoids duplicate recording of a single case, which could overestimate the incidence rate in various summaries. Computer programs can eliminate such duplication and produce more uniformity in coding across systems.

The USDA Animal Improvement Programs Laboratory (2004) has drafted a set of standardized health trait terms for recording disease events on dairies. If widely adopted, those terms should help make recording of diseases more consistent, and comparisons between dairies more reliable. For the most part, the diseases included (e.g., diarrhea, displaced abomasum, dystocia, ketosis, lameness, mastitis, milk fever, respiratory problem, retained placenta, teat injury, udder edema) are those common to dairy cows and ones that can be reliably identified by a clinical examination of the cow by workers on the dairy or noted during routine scheduled veterinary examinations. Thus, the diseases reported are those identified from observable signs, not by the causative agent; the one exception is Johne's disease. Currently, the Animal Improvement Programs Laboratory receives dystocia and stillbirth data (Van Tassell et al., 2003) in separate files from the lactation and reproductive records. The proposed new format for data exchange of health traits would complement the data currently in the national database.

Recommendation. The DHI dairy records processing centers should adopt the recently developed USDA Animal Improvement Programs Laboratory's listing of health trait terms to create a national database for research. Most of those new traits have considerable economic impact on dairy profitability, and a few of them are likely to provide an opportunity in the future to reduce forced culling. We recommend that dairy extension agents, consultants, veterinarians, and producers encourage more extensive recording of health traits through the national DHI record system.

USING ESTIMATES OF CULLING MAGNITUDE

Different concerns about the magnitude of culling arise when considering the national herd and individual herds.

National Herd

On a national basis, the number of cows that were culled in a given year can be calculated as

$$(\text{national herd size at year's start} - \text{national herd size at year's end}) + \text{number of heifers that calved for the first time during the year.}$$

The average herd size for the year can be estimated as

$$0.5 \times (\text{national herd size at year's start} - \text{national herd size at year's end}).$$

The annual national herd turnover rate is then

$$\text{Number of cows culled} \div \text{by the nation's average herd size.}$$

This calculation necessarily excludes cows sold for dairy purposes from one dairy to another. If the national dairy herd had 8.9 million cows at the beginning of the year and 8.8 million cows at the end of the year and if 3 million heifers calved during that year, the year's cull rate would be

$$\text{Cows culled} = (8,900,000 - 8,800,000) + 3,000,000 = 3,100,000$$

$$\text{Average national herd size} = 0.5 \times (8,900,000 + 8,800,000) = 8,850,000$$

$$\text{National herd replacement rate} = 3,100,000 \div 8,850,000 = 35\%.$$

As this calculation shows, turnover rate at the national level is inevitably determined by the change in the national dairy herd size and the supply of available heifers. Unlike the beef cattle industry, almost all dairy heifers are reared as herd replacements, because the economic value of a dairy heifer as a replacement far exceeds the alternative value in the beef slaughter market. If national herd turnover increases during a particular year, it can only have come about by reducing the size of the national herd or by increasing the supply of new heifers to calve. The supply of heifers available to calve can be increased either by reduced heifer mortality, increased cow reproductive productivity (shortened mean calving interval), imported heifers, or shortened

time for heifers to reach calving age. An increase in the national turnover rate does not mean that the dairy industry has been damaging cows at an increased rate or that production stress is driving cows to slaughter. Nationally, higher turnover rates may reflect nothing more than improved heifer rearing, so this is another reason that replacement rate seems to be a more appropriate term than culling rate.

Individual Herds

At the individual herd level, several basic questions typically are addressed using estimates for culling magnitude.

If the capacity of a dairy is N adult cows, how many replacements will be needed in a typical year? This question can be answered by multiplying the herd turnover rate times the capacity N . For example, assume a herd capacity of 1,000 adult cows and a herd turnover rate of 33%. The estimated number of replacements that will be needed during the coming year is $1,000(0.33) = 330$.

If a dairy calves 100 animals, how many will start another lactation after this one? This number can be estimated by converting an annual turnover rate to a lactation rate (in this case, lactation refers to the interval between calvings, not just the milking phase). The annual rate divided by 12 provides an estimate of the monthly turnover rate of cows on the dairy. Multiplying this number by the mean calving interval gives an estimate of the lactation turnover rate experienced by the dairy over the past year. If the conditions on the dairy remain similar, then this projection of culls per lactation is a fair estimate of what will occur. For example, assume a herd of 100 cows, annual herd turnover rate of 36%, and mean calving interval of 14 mo. The estimate of the lactation turnover rate would be $(36/12) \times 14 = 42\%$.

Alternatively, the lactation culling risk could be determined by following a cohort of animals (retrospectively) from calving for that lactation until they either calved again or were culled. Estimating mean time between lactations can be done directly by computing the mean time from one calving either to the next calving or to a cull event. Unfortunately, this approach would necessarily include some distant historical calving data for the herd that may no longer represent the herd. If the calculation is done from one calving to the next, it only considers that portion of the herd that has had 2 calves or more (first-lactation animals and animals culled at the end of lactation have not had a second calf).

If a dairy is in the midst of an expansion, does the calculated turnover rate describe what is happening and does it predict removal rates into the future? The

preferred calculation of herd turnover rate works for expanding herds as well as for stable herds for describing what has occurred. It does not necessarily serve as a reliable estimate of what turnover rates will be experienced in the herd in the future, however. To fill new facilities, expanding herds often voluntarily choose to limit culling of cows that under other circumstances might exit the herd. Those cows may not be desirable in the long term but serve short-term needs, particularly in terms of cash flow. As the dairy fills and cash flow improves, significant financial incentive may arise to replace those cows with better animals, which would raise the turnover rate in the dairy above earlier levels seen during expansion. In addition, expansions typically fill the barn with first-lactation cows. During the first year, fewer of those cows will be culled, partly because they will not yet have completed their first lactation. During the second year of expansion, culling may increase suddenly in this cohort, either because they were low producers that did not warrant a second lactation or because of routine risks around the time of second calving.

How does turnover on my dairy compare with that of other dairies—am I culling too much or too little? Even though this question is probably the most common asked in regard to culling statistics, it is also the most difficult to answer. Given the charge of the subcommittee, addressing this question in any depth is probably outside its purview, but a few general statements might be in order.

Within the dairy literature, the consensus is that lower annual turnover rates are more profitable, with optimal turnover rates of $\leq 30\%$ based on modeling or surveys of dairy farm financial records (Allaire, 1981; Congleton and King, 1984; van Arendonk, 1985; Williams et al., 1987). However, no single turnover rate is optimal for all herds or for all years. Turnover rates are the net result of a series of culling decisions made each day for individual cows. Those decisions are derived ideally from considerations of economics (milk price, cull price, replacement costs, etc.), farm capacities, health and productive status of the individual cow, disease and death rates within the herd, available replacements, and biosecurity considerations, among others. If the dairy has made optimal culling decisions cow by cow, then the resulting turnover rate is ideal for that dairy at that time. However, sustained high turnover rates should stimulate an investigation to identify herd risk factors that devalue cows prematurely within the herd; for example, mastitis, infertility, lameness.

Herd summary statistics, including herd turnover rate, should not be used in isolation to evaluate herd performance. Looking at a culling statistic for a dairy in isolation and concluding that the rate is either too

high or too low can lead to serious misjudgments. For example, a turnover rate of 25% does not reflect good herd management without knowing the productive, reproductive, and health status of the herd and the economic conditions under which that culling statistic was achieved. It might instead reflect an inability to keep replacement heifer calves alive or an inability to finance the purchase of needed replacements.

Considerations of culling are necessarily a retrospective or historical activity. In the case of annualized rates, the events that ultimately lead to a cull often happen as much as a year or more before the culling event itself. Thus, a case of ketosis, fatty liver, and left-displaced abomasum may lead to poor production and subsequent culling after 16 mo of lactation. If the culling event happened 11 mo ago (and thus was included in the current herd turnover rate), then the actual management breakdown for the prefresh transition program that is now being included in the statistic happened more than $16 + 11 = 27$ mo previously.

CONCLUSIONS

To improve the quality of culling records and the clarity of discussions on the topic, several recommendations and comments regarding culling records and terminology have been offered. Dairy records systems should categorize removals by destination first (dairy sale, slaughter/salvage, or death) and then allow selection of multiple predefined specific reasons to help characterize the removal of individual cows. The preferred term to represent the magnitude of removal is "herd turnover rate." If subgroups of culled cows are discussed, their removal incidence should generally be described as a subgroup turnover rate rather than as a percentage of culled cows. The traditional distinction between the 2 categories voluntary and involuntary culling has not been useful for management purposes, and should be discontinued. Although herd turnover rate can reflect overall herd health management, turnover rate should not be used in isolation to assess herd health. Although removal reasons have use in monitoring herd management programs, disease monitoring systems offer more sensitive and timely information than culling records. The DHI dairy records processing centers should adopt the recently developed USDA Animal Improvement Programs Laboratory's listing of health trait terms to create a national database for research.

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