EFFECT ON MILK PRODUCTION AND INCOME OVER FEED COST FROM FOLLOWING LESS THAN OPTIMUM MANAGEMENT STRATEGIES RELATED TO DAIRY COW REPLACEMENT

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INTRODUCTION

Dairy farmers, as profit maximizers, are constantly striving to expand the income producing ability of their dairy herds. As managers of their business, their direct concern is to attain high production per cow and enhance the average quality of their herd by removal of the unprofitable producers. They are also striving to earn a large income above feed costs, since feed costs comprise 50 percent or more of the costs of production. This value must be high enough to pay for the other costs of production, including a return to capital and operators labor, to return a profit. Proper culling or the identification and subsequent removal of the lower producing cows from a herd is important because of the increased average milk production and the resulting increased income above feed costs.

In addition to culling strategies themselves, management strategies related to culling may also be of importance to dairymen. For example, at what point in the lactation is the most profitable time to remove a potential cull, and what loss in average milk production and income will be incurred by culling at some time other than the optimum? Under herd expansion programs where culling rates are reduced, what losses in milk production and income over feed cost will result under alternative culling rates? Many dairymen breed their heifers to beef bulls. To what extent does this practice hamper the ability to select replacements with subsequent reduction of average milk production and income? This study is an attempt to examine the above questions.

To study how various strategies of culling dairy cows and related management practices affect factors such as income above feed cost and average milk production per cow over time, it is necessary to establish population parameters which conform to the variables under study. Simulation is one possible method which provides a look at the intermediate effect of two to three years as well as examining the effect of these factors after ten to fifteen years when future generations of these cows selected to remain in the herd come into production. In contrast to actual current production records, simulation procedures permit certain variables not under study to be fixed while those subject to uncertainty can vary at random.

EXPERIMENTAL PROCEDURE

The present study utilized the same computer simulation program as Rundell [6] in which he examined replacement strategies among six operationally practical systems of culling cows over a fifteen year period. Three of the six culling strategies from that study were retained for the majority of this study, namely: (1) Mature Equivalent Milk (M. E.)[1] (305 days), (2) Actual Milk (305 days), and (3) Actual Income Over Feed Cost (365 days). The cows were ranked yearly on each current extended 305 day record according to the determined strategy which was constant throughout the fifteen years of each trial. The bottom ranking cows were then culled, until at the end of the year, the herd equaled eighty cows for those trials specifying a relatively constant

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[1] Prediction of cow's production ability as a mature cow.

herd size. Prices for milk and feed used as parameters represented approximate low and high values respectively on Southern Michigan farms in the 1960's. Fat differential was $.075 and operational costs were $23.65/cow/month, while cull beef price was $16/cwt.

This study treated certain elements as stochastic. They were as follows: (1) variations in milk production and milk fat percentage among cows and among lactations of the same cow (normal distribution), (2) chance of a calf being a heifer or bull, (3) chance of involuntary death or removal of cows and youngstock, and (4) chance of month of year of involuntary removal or death. To achieve the stochastic element, random numbers were generated. The probability of involuntary removal and deaths were derived from a study by Dayton [2]. Voluntary culls are those removed due to low production or low ranking, while involuntary culls are those removed due to sterility, mastitis, etc.

The basic program in simulation of the base herd and subsequently the offspring generated a value based on M. E. milk production. Therefore, certain correction factors were necessary to convert the M. E. to actual milk production. In such a reverse process, the reciprocal of the standard USDA age correction factors was utilized to simulate the 305 day actual record for each cow. Partial records for cows when needed were also compiled by a reciprocal of the USDA extension factors.

Assumptions

1. All cows freshen on September 1 and lactate for 10 months unless removed by death, involuntary cull, or voluntary cull.
2. All heifers freshen at 2 years of age and, if they remain in the herd, maintain a calving interval of 12 months.
3. All deaths, involuntary and voluntary culls take place at the end of the month.
4. Cows are ranked once per year on their "potential" 305 day record. As part of the simulation program, however, low ranking cows were removed on the basis of their "extended" record.
5. All replacements are raised.
6. Identical lactation curves were assumed for any given 305 day milk production record.

The variance for both milk production and fat percentage and their correlation was chosen as a relevant characteristic. The variances of milk production used to generate the base herd were described by Everett, et al. [4], while correlation of milk with fat percentages were taken from data by Butcher et al. [1].

The control trials consisted of the three culling strategies, two levels of milk prices ($4.25 and $5.25), two feed prices as mentioned before, and salvage price of $16.00 cwt., thus constituting 3 x 2 x 2 x 2 replications, or 24 runs of fifteen years each. The various management strategies and prices under study deviated from this as explained below.

Culling Rates

Dairymen expand their herds by reducing culling rates and/or by purchasing cows or heifers. In this study the control trial maintained a relatively constant herd size (approximately 80 cows at the end of the year). To compare with the control, voluntary culling rates were set at 15 percent, 10 percent, 5 percent, and 0 percent, respectively. For 10 percent, 5 percent, and 0 percent cull rate trials, however, cows were culled at these respective rates from year four until the year in which the herd size reached 160 at the end of the year.

Saving No Replacements From Two Year Olds

To simulate the practice of some dairymen who breed their heifers to beef bulls, one study compared the control trials with trials where no replacements were saved from the two year old cows. In each case, the three standard culling strategies were utilized.

Month of Culling

Under the controlled method, voluntary culls were removed from the herd at the most profitable time in the lactation or when marginal cost of feed plus operational costs equaled marginal revenue. To simplify simulation, however, heifers were not available until the beginning of the next year.

Using all three standard culling strategies, three alternate times of removing the potential cull within her lactation were studied. Namely, (1) optimum month plus one month, (2) optimum month minus one month, and (3) culling on a random month (one through ten).

Milk Prices

Using all three culling strategies, three different levels of milk prices were compared, namely: $4.25, $5.25, and $6.25 per cwt.

Estimated Producing Ability

One additional culling strategy was tried to compare with the three standard ones used

throughout the rest of the trial. For this one EPA (Estimated Producing Ability) as explained by Eastwood [3], was used to rank the cows. It is formulated for the i^{th} cow as shown below.

$$\frac{rn}{1 + r(n-1)} \sum_{j=1}^{n} \frac{(X_{ij} - AHA_{ij})}{n}$$

where:

- r = the simple average of the simple coefficients of correlation between production levels of successive lactations,
- n = the number of lactations completed by the i^{th} cow,
- X_{ij} = production of the i^{th} cow in her j^{th} lactation, and
- AHA_{ij} = the adjusted average production of the i^{th} cow's herd-mates during her j^{th} lactation.

Salvage Price

A price of $16.00 cwt. was used as the price of cull cows throughout all trials with the exception of a special study. Here the effect on income over feed cost and milk production was compared under cull prices of $11.00, $16.00, $21.00, $26.00, and one in which beef prices cycled yearly at random. The latter trial started at $16.00 in the first year of each simulated run of fifteen years. Price of salvage then in year i + 1 = i price + random deviate times 2.56 which approximates the standard deviation of yearly Michigan cull prices in the 1960's, where i = year one through fifteen.

Statistical Analysis

The present value of income (including salvage) over feed cost per cow and actual milk production per cow was used as the major criteria to compare the various dairy herd management strategies related to culling. Standard discounting procedures were used to discount (at 6 percent) the future income obtained from the herd back to the present [7].

Analysis of variance in a factorial arrangement was used to test the difference in results. The hypothesis tested was that there was no difference in milk production, income over feed cost, and other related factors between the various management strategies.

RESULTS AND DISCUSSION

Culling Rates

The present value of income over feed cost, actual milk production, and income over feed cost differed ($P < .01$) by culling rates as seen from Table 1. Average herd size as measured by cow months divided by twelve varied from 99.3 for the control to 169.4 for no culling. As measured by income over feed cost plus salvage income, a dairyman would lose approximately $20 per cow per year ($452.15 minus $432.15) by changing from constant herd size to a 15 percent cull rate and $27 by reduction to a 10 percent cull rate (Table 1). In the 100 cow range this could amount to a $2,000 loss per herd per year. From a level of 14,317 pounds milk production per cow per year under a constant herd size, production dropped 253 and 369 pounds per cow per year when culling at 15 percent and 10 percent respectively. There was little additional reduction in milk production with the 5 percent culling rate and no culling.

Saving No Replacements From Two Year Olds

Despite the fact that dairymen are advised not to breed their heifers to beef bulls, many still follow this practice in order to reduce calving difficulties for first calf heifers. This study attempted to compute the opportunity cost of such a practice. Between the control trial and the trial in which no replacements

Table 1. VALUES OBTAINED UNDER DIFFERENT CULLING RATES (PER COW PER YEAR)

Cull Rate Estb.	Herd Size**	Discounted Income/Feed Cost**	Income Over Feed Cost + Salv.**	Income Over Feed Cost **	Actual Milk** (lb.)	Result. Ave. Cull Rate (%)**	Gross Income**
control	99.3	$294.82	$452.15	$383.53	14317	20.16	$680.16
15%	124.9	280.97	432.07	377.56	14064	11.24	670.47
10%	161.9	275.74	425.17	372.39	13948	13.22	664.70
5%	166.1	275.00	424.98	372.34	13939	13.15	664.60
0%	169.4	274.24	424.25	371.54	13929	13.32	663.52

**Significant ($P<.01$)

were saved from the two year olds, there was a difference of \$10.81 ($P < .01$) in discounted income over feed cost per cow per year (Table 2A). Average income over feed cost (plus salvage) for the 15 year period was reduced from \$452.15 to \$433.14 by not saving replacements from two year olds. With a 100 cow herd, this latter figure would amount to a loss of \$1,901 per year. Average milk production was reduced from 14,317 pounds to 14,167 pounds per cow, a difference of 150 pounds ($P < .01$). Such a loss in income and milk production comes from the greatly reduced ability to remove the lower producing cows from the herd and reduction of income from the cull beef. The difference in income over feed cost per cow was only \$4.07 and significant when salvage value was added, the difference was \$19.01. The voluntary cull rate was reduced from an average of 20.1 percent to 12.7 percent. Table 2B has broken down actual milk by culling strategies and control vs. saving no replacements from two year olds. The greatest difference in milk production (178 pounds) between these management practices is under the culling strategy of actual milk.

Month of culling

To maximize profit from a dairy herd, it is important to know at which point in the lactation to cull. A potential cull can return a profit if she is removed from the herd before her marginal costs exceed her marginal revenue. A cow's potential 305 day milk production, likewise, can be predicted from a four or five month record. As long as milk sales exceed the cost of feed, labor, other variable costs, and fixed costs, it would pay to keep a potential cull another month. If the dairyman has plenty of space and no replacements to immediately take the place of the cull cow, then only the variable costs should be considered and not the fixed or operational costs as charged in this computer program.

Operation in the long run, however, requires that all costs including fixed charges must be covered. If a dairy herd is to achieve maximum profit over time, cows must be removed at the point where the returns equal total cost.

Table 3 shows the different values obtained by culling the voluntary culls at (1) optimum month (control, where milk income equaled variable and fixed costs), (2) optimum month plus one month, (3) optimum month minus one, and (4) culling on a random month (one through ten). Discounted income over feed cost differed ($P < .01$) among these times amounting to \$294.82, \$292.76, \$297.21, and \$298.47 respectively. Milk production also differed ($P < .01$) among these management practices resulting in 14,317 pounds, 14,252, 14,370, and 14,345 pounds per cow respectively.

Total herd income over feed cost also differed ($P < .01$) by cull month (Table 3), but the ranking was somewhat reversed. Under the simulation procedure, when cows were culled, there were no replacement heifers to take their place until the beginning of the next year. Thus, total herd milk production and

Table 2A. COMPARISON OF CONTROL AND SAVING NO REPLACEMENTS FROM TWO YEAR OLDS

	Discounted Income Over Feed Cost**	Income Over Feed Cost + Salvage**	Income Over Feed Cost**	Herd Size**	Actual Milk** (lb.)	Cull Rate**
Control	\$294.82	\$452.15	\$383.53	99.3	14317	20.1%
No Replacements 2 year olds	284.01	433.14	379.46	92.7	14167	12.7

**Significant ($P < .01$)

Table 2B. COMPARISON OF MILK PRODUCTION BETWEEN CONTROL AND SAVING NO REPLACEMENTS FROM TWO YEAR OLDS BY CULLING STRATEGIES

	Actual Milk	
Strategy	Control	Save No Replacements
Mature Equivalent	14341 lb.	14210 lb.
Actual Milk	14386	14208
Income Over Feed Cost	14224	14084

Table 3. VALUES OBTAINED UNDER VARIOUS CULLING MONTHS

Cull Month	Discounted Income Over Feed Cost**	Income Over Feed Cost + Salvage** (per cow)	Income Over Feed Cost + Salvage** (per herd)	Income Over Feed Cost**	Actual Milk (lb)**	Herd Size	Cull Month **
Optimum(control)	$294.82	$452.15	$45,137	$383.53	14317	99.3	6.78
Optimum + 1	292.76	448.44	45,971	381.85	14252	101.0	7.73
Optimum – 1	297.21	455.47	44,704	385.45	14370	97.2	5.77
Random	298.47	457.71	42,234	384.32	14345	92.2	5.52

**Significant ($P < .01$)

income suffered. By Duncan's Multiple Range Test, all herd incomes were different ($P < .01$) from each other with optimum + 1 earning the greatest return ($45,971). Where heifers are not immediately available, it is thus more profitable to keep potential culls at least a month beyond the point where all costs including all fixed costs are covered. Such cows need only to cover their feed and other variable costs.

Milk Prices

In all of the previously discussed trials in this study, two alternate prices of milk were used, $4.25 and $5.25, and in most cases the results were averaged over these two trials. Table 4 has broken down these two prices along with one more price of $6.25. Discounted income over feed cost per cow raised from $250.59 to $339.07 and $428.02 respectively when milk prices were increased.

Culling Strategies

Table 5 presents the values obtained by comparing the three culling strategies used throughout the trial plus one other strategy, Estimated Producing Ability (EPA). There was no significant difference among these four strategies in discounted income over feed cost, income over feed plus salvage, or income over feed cost. There was however, a difference ($P < .01$) in actual milk production which ranged from 14,224 pounds per

Table 4. VALUE OBTAINED UNDER ALTERNATE PRICES OF MILK

Price Milk/Cwt.	Discounted Income Over Feed Cost**	Income Over Feed Cost + Salvage**	Income Over Feed Cost**	Actual Milk (lb)**	Herd Size	Cull Month**
$4.25	$250.59	$385.42	$314.26	14375	95.9	5.20
5.25	339.07	518.87	452.79	14259	102.6	8.36
6.25	428.02	653.97	589.62	14120	104.68	9.38

**Significant ($P<.01$)

Table 5. COMPARISON OF CULLING STRATEGIES

Strategy	Discounted Income Over Feed Cost	Income Over Feed Cost + Salvage	Income Over Feed Cost	Actual Milk (lb)**
Mature Equivalent	$294.33	$451.57	$381.92	14341
Actual Milk	294.88	451.97	384.29	14386
Income Over Feed Cost	295.26	452.91	384.37	14224
Estimated Producing Ability	296.57	454.66	385.77	14397

**Significant ($P < .01$)

cow under the strategy of income over feed costs to 14,397 pounds under the strategy of EPA.

Several factors may account for the similarity of results between strategies. First, many cows which rank low in M. E. milk production will also rank low in actual milk production. Second, for some borderline cases, removing lower producing young cows in a herd, even though their M. E. would be greater than an older cow, leaves the higher production of the more mature cow in the herd, thus adding more to current production. Third, regardless of strategy, cows will be culled at the approximate same point in their lactation curve; that is, where added income equals added cost.

Maximum genetic progress within a herd by culling is only about 6 percent. A dairyman's most important gain from his female herd comes from removing the unprofitable cows, not genetic progress.

Simple strategies such as those based on actual milk should appeal to most dairymen in that they are easy to use and understand and need no special adjustment factors. Such strategies can apply from simplified DHI reports or simply milk weights. If dairymen knew they would not sacrifice profit by using such strategies, they may wish to employ these simple culling policies. Errors in age adjustment factors, which admittedly differ from herd to herd, region to region, and cow to cow are eliminated when using actual records.

Under practical conditions, EPA may have some added appeal as a culling strategy, in that temporary environmental conditions affecting records are considered, rather than just the current record of the cow.

Salvage Prices

There was no difference in average milk production under salvage prices of $11.00, $16.00, $21.00, $26.00, and cycling prices. As would be expected discounted income over feed cost and income over feed cost plus salvage differed ($P < .01$) by salvage prices (Table 6).

SUMMARY

This paper shows the effect of following less than optimum management strategies related to dairy cow replacement. Averaged over 15 years, a loss of income above feed cost of $20 and $27 per cow per year results from changing from a constant herd size to 15 percent and 10 percent culling rates, while milk production per cow per year dropped 253 and 369 pounds respectively. By saving no replacements from first calf heifers, average income over feed cost (plus salvage) was reduced $19 per cow per year while milk production was reduced by 150 pounds per cow per year. The most profitable time to cull within a lactation from a herd basis appears to be one month later than so called "optimum month" (when marginal cost equals marginal returns) because of the manner in which operational costs were charged. There was no difference in discounted income over feed cost or income (including salvage) over feed cost when comparing four culling strategies, but there was a difference ($P < .01$) in average milk production per cow. Different milk prices affect ($P < .01$) average milk production over time while different salvage prices do not.

Many factors, however, could change the above data whereby farmers could lose more or less income than indicated. A higher involuntary cull rate, for example, could reduce significantly the cows available for voluntary culling. Thirteen month calving intervals rather than the twelve month assumed here could also reduce the turn-over rate over time. In

Table 6. VALUES OBTAINED UNDER DIFFERENT SALVAGE RATES

Salvage Price (cwt)	Discounted Income Over Feed Cost**	Income Over Feed Cost + Salvage**	Income Over Feed Cost*	Actual Milk
$11.00	$282.77	$432.50	$384.83	14356
16.00	294.82	452.15	383.53	14317
21.00	309.98	475.72	384.49	14347
26.00	321.92	494.81	383.24	14287
Cycle	291.00	445.08	384.13	14337

*Significant ($P < .05$)
**Significant ($P < .01$)

addition, different cull beef prices and different milk prices may also affect the extent of loss by following less than optimum dairy herd management practices related to culling.

This simulation program assumed that all cows with a given milk production generate the same lactation curve. If one relaxes this assumption, it could change considerably the optimum time within the lactation to remove a potential cull. Numerous milk records confirm that cows do deviate around the normal lactation curve. Yet under actual herd conditions, we are not worried as much about the shape of the curve (except for maybe persistency) as we are the predicted 305 day record as extended from the sixth or seventh months of the lactation, or the most profitable time to remove the cow.

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