Available online at www.easletters.com

ISSN No: 2349-2864

Entomology and Applied Science Letters, 2016, 3, 3:41-46

Culling or Replacement of dairy cows in herds based on the expected future values

Reza Seyedsharifi, Jamal Seifdavati and Bahram Fathi Achachlouei

Assistant Professor of Animal Science, Faculty of Agricultural Sciences and Natural Resources, University of Mohaghegh Ardabili, Ardabil, Iran

ABSTRACT

The basis for deciding to replace a dairy cow that produces several lactation periods in cattle, with a heifer that has recently experienced its first calving, is the comparison of the present values of these two cases. In order to estimate the expected statistics under the optimized policy, Markov chain simulation as a dynamic programming was used. The objective function was to maximize the present net value of cows in a planning horizon with 10 lactation periods. It was observed that with increasing the calving interval, the future value is less produced from the ideal condition that originates from increasing the probability of involuntary culling that intensifies with age. Meanwhile, according to the results, with cow growth, its future value decreases. Therefore, it can be said that future value changes with age, production level, and lactation period.

Keywords: present value, future value, replacement and culling, dynamic programming, dairy cow

INTRODUCTION

Industrial dairies have a large share in the production of milk and meat for satisfying the needs of the country. Generally, 25 to 35 percent of dairy cows herds in each year will be replaced by heifers. In dairy farms, most of the young heifers need to be replaced and the purpose of breeding alternative heifers is to increase future profitability. Therefore, management decisions can affect the profitability of cow units. The basis for replacing a dairy cow that produces several lactation periods in the herd with young heifer that has recently experienced its first calving, is to compare the present value of these two options. It should be mentioned that the expected net value of a cow will be maximized under the stable influence of herd size. It means that a heifer enters the herd when a cow is culled and this is one of the important assumptions is applying dynamic programming. Dynamic programming is applied extensively to determine replacement under various circumstances. In this method, the cash flow (income and expenses) discounts based on occurrence time (income or expense). Identifying the cow that must be removed, removing it from the herd, and replacing it with a heifer constitute the removal process. Awareness of the removal effect on production, the number of removed cow, the cause of removal and the effect of management plans on the removals are of great importance [5]. The determination of present value of an income or expected cost is discounting and the related profit is called discount rate. Stewart et al., (1997) reported that with increasing discounting factor (decreasing discount rate), older cows are removed more than younger ones and the percent of removed cows increases. Cardoso et al., (1999) reported that the future profit changes with any change in age, production level, and lactation period. Future profitability change curve during lactation month shows that future profitability of cows at the beginning of lactation is high due to selling calf and decreases during lactation period. However, at the end of lactation, due to the expected value of a calf, the curve increases a little bit, so that it can be said that the future profitability of a cow during lactation period is the reverse of the lactation curve. The purpose of the present study is to investigate the effect of culling or replacement of dairy cows in dairy herds based on the future expected values using dynamic programming model.

MATERIALS AND METHODS

In this study, to make optimal decision regarding maintaining or replacing dairy cows, probable dynamic planning is used. The reason for using probable dynamic programming is the dynamic nature of issue as well as uncertainties involved in the issue.Dynamic programming is a mathematical method to solve problems with several successive stages of decision-making.In this study, the planning horizon consists of 10 lactation periods and each period is considered as a decision-making stage. In each stage, dairy cows were considered through their conditional variables including production capacity at three levels (low, medium, high) with the production lower than 5000 kilogram, 5000 to 7000 kilogram, and more than 7000 kilogram that included 0/02%, 0/35%, and 0/63% of cow, respectively. The reproductive performance was described at 4 calving intervallevels of 410 days, 450 days, 490 days, and 530 days. Finally, an objective function was defined to maximize the present net value of cow. To express conditional variables, St state vector is defined as follow:

$$S_t = [s_t^{parity}, s_t^{prod}, s_t^{repro}]$$

In this vector, the number of lactation periods in identified by s_t^{parity} that ranges from 1 to 10. Since we replace the cow voluntarily in the last lactation period and the value of such a cow will be obtained from slaughteringvalue, then the system value at the end of planning horizon will be considered as zero. Production capacity with the character of s_t^{prod} includes 3 states including: 1 for low production; 2 for medium production; and 3 for high production. s_t^{reprod} is related to conception situation that consists of 4 states. State (1) is for ideal situation or lack of delay in conception. States (2), (3), and (4)are considered for 40, 80 and 120 days delay in conception. The acceptable domain for DFBC is considered between 0 to 120 days and the data that were not in the domain were removed. The following relationship was used for optimal decision-making:

$$PV_t(s_t) = \max_{at} \{\sum_K P_t(k_t)[R_t(s_t, a_t) + \delta V_{t+1}(s_{t+1}, a_t)]\}$$

$$t = T-1, T-2, \ldots\ldots\ldots, 1$$

$$\sum_K P_t(k_t) = 1$$

In this relationship, $PV_t(s_t)$ is the maximum expected value of the objective function along the planning horizon under replacement optimal policy in state S_t and lactation period *t*. If it is decided to maintain or replace cow, and there be the probability of random variables transmission (production and reproduction) $P_t(k_t)$, lactation period output t will be $R_t(s_t, a_t)$. In addition to this system, in lactation period, $t+1$ will be transferred to $V_{t+1}(s_{t+1}, a_t)$. Therefore, St+1 is dependent on Vt.It should be mentioned that to estimate future value (FV) of a sum of expected present value(PV) with a percent rate (r) after n years, the following relationship was used [4]:

$$FV = PV(1+r)^n$$

In this study, GENMOD procedure from SAS (2001) software was used to estimate probabilities related to each of the conditionsspecific to conception in which binominal distribution and logic link function were used.Since optimization techniques need models that should be performed for several times to obtain optimal response, the optimal decision was estimated numerically in MATLAB using CompEcon Toolbox with tandem repeat technique[12].

Table 1. The value of parameter used in basic scenario

Data	Values in basic scenario
Milk	9500 Rial (Kg)
Calf value	25000000 Rial
The cost of replacement calf	60000000 Rial
The cost of insemination	600000 Rial
Discount rate	20%

RESULTS AND DISCUSSION

The expected present value shows objective function value in dynamic planning. So that, if the expected present value of the dairy cow in herdis lower than a heifer, replacement will be performed. Otherwise, the dairy cow will stay for one more period in the herd to wait for the decision by the beginning of the next period. In other words, optimal decision will be obtained through comparing the present value of cow future cash flow in herd with the present value of its alternative heifer future cash flow. Finally, the one which has the higher value will dedicate the unit to itself.The results of investigation in low production group showed that the present value has increased until the third conception, then reduces. This trend is economically justified by the seventh conception. In medium and high production groups, the present value increases until the second conception and after that declines. This trend is justified until the eighth conception. Also, it is observed that with increased calving interval, the present value decreases, but optimal decision in any production level is equal for various calving intervals. It is observed that with increased conceptions (getting older), the amounts of removal increase. Considering 10 conceptions in model, indeed we will not see the 11^{th} conception. In 10^{th} conception, the future is not imagined for the cow. The system value in this stage equals salvage value. So that, the system value, by the end of the planning horizon, will not affect decision-making and it is possible to consider it as zero. For the 9^{th} conception, since the 10^{th} conception is expected, the removal rate will be higher compared to other conceptions. Figure (1) shows the expected present value using optimal replacement strategy for the three groups of interest of cows in this study. So that, in this figure, the lines related to production levels are located separately and by the addition of production level, the present value increases. One of the fundamental criteria in estimating the expected present value is the arrangement of available cows in herd based on their future value and costs by which the decision regarding removal and maintenance will be taken. Therefore, without considering these values, soon or later, these cows will be removed and this leads to decreased profitability [2].

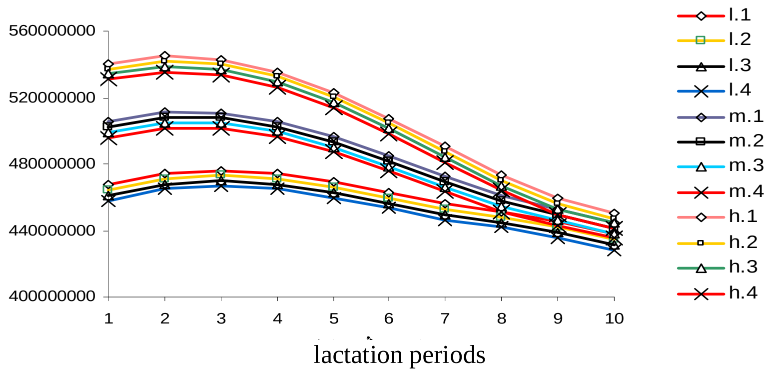

Fig. 1. The results of investigated model regarding maintaining or replacing dairy cow based on the expected present values

l1: low production + low interval of ideal birth, l2: low production + 40 days delay in conception, l3: low production + 80 days delay in conception, l4: low production + 120 days delay in conception, m1: medium production + ideal birth interval, m2: medium production + 40 days delay in conception, m3: medium production + 80 days delay in conception, m4: medium production + 120 days delay in conception, h1: high production + ideal birth interval, h2: high production + 40 days delay in conception, h3: high production + 80 days delay in conception, h4: high production + 120 days delay in conception.

As can be seen, the expected present value will be obtained from all values and costs in next lactations as well as values and costs of the replaced cow. The use of various MARKOV simulation models that estimate the future probabilities through recent values and also dynamic programming models to support decision-making, a replacement based on production and reproduction in dairy cow units has been reported [6]. The lack of using optimal alternative decision leads to profitability of cow unit.

To use the dynamic programming results, a concept called “the future value” is used [16]. When a producer wants to decide regarding removal or replacement of a cow, it is necessary to compare the expected profits and values to maintain or replace the cow with another one. The profit that a cow will probably produce in the future is different in various lactation periods.

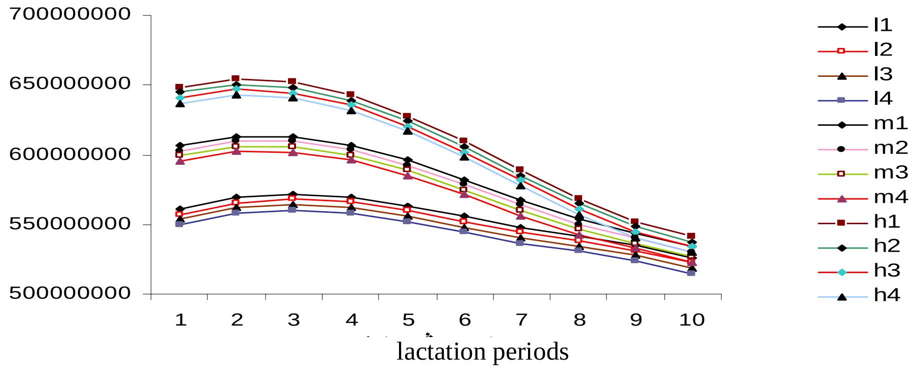

Fig. 2. The results of investigated model regarding maintaining or replacing dairy cow based on the future values

Through investigating figure (2), it is observed that with increasing the birth interval, the curves are drawn towards downside and this indicates decreased future value of cow with increasing calving interval. With increasing calving interval, the future value experiences less interval regarding ideal condition that stems from increased probability of involuntary removal that increases by age. Meanwhile, it is observed that with cow ageing, the future value decreases. Therefore, it can be said that the future value changes with age, production level, and lactation period. Figures (3), (4), (5), and (6) show future values in various lactation periods for all three capacity groups with ideal conception condition and 40, 80, and 120 days delays of conception.

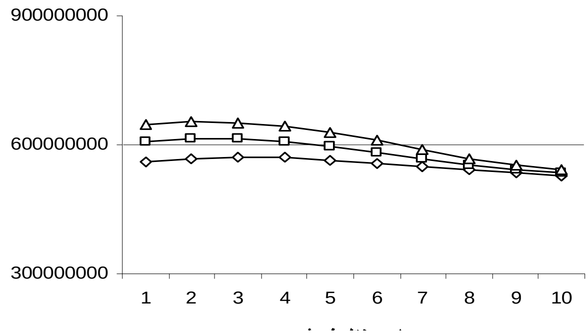

Fig. 3. The future value in various lactation periods for three capacity groups with ideal conception condition

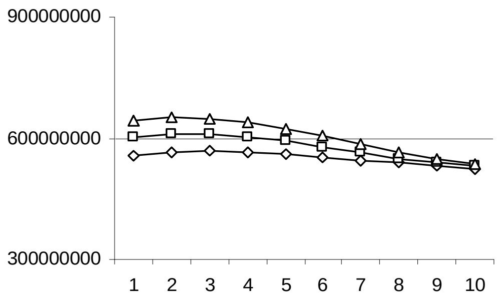

Fig. 4. The future value in various lactation periods for three capacity groups with 40 days delay in conception

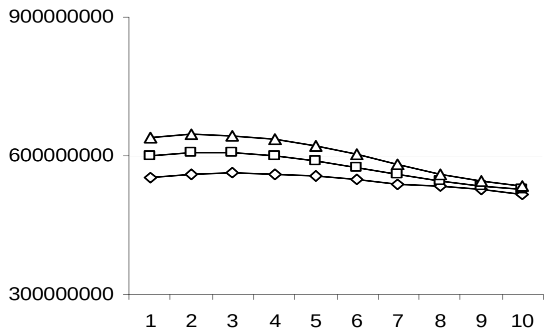

Fig. 5. The future value in various lactation periods for three capacity groups with 80 days delay in conception

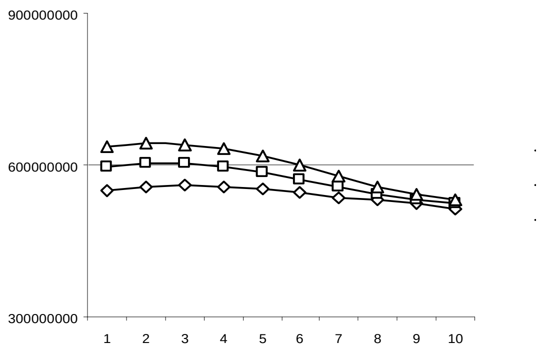

Fig. 6. The future value in various lactation periods for three capacity groups with 120 days delay in conception

Figure (7) shows the differences between future and present values under the discount rate of 20 percent. The present value in the future is the value that is for the producer by now. The present value of 467218211/5 million rial with an interest rate of 20% will bring 560661853/8 million rial value. Therefore, after one year, the present value of 467218211/5 million rial will be 389348509/6 million rial by today. Thus, with the interest rate of 20%, the present values of today's 389348509/6 million rial and 467218211/5 million rial will be equal by the next year.

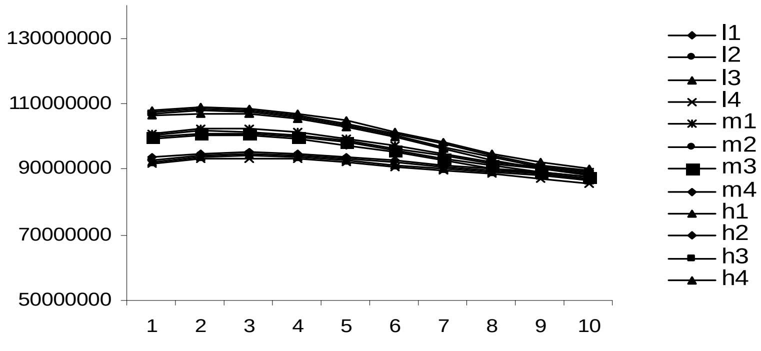

Fig. 7. The difference between the present value and the future value under the discount rate of 20%

The optimal mean life of herd (interval between first calving and removal) for the described costs was obtained in basic scenario of 4/99 years (60 months) that reflectscow's resistance against voluntary and involuntary removal[17]. The optimal life of the herd in this study was higher than the estimated value by Kalantari et al., (2010) and the reason is due to differences in market condition at the times of these two investigations. It should be noted that increasing the age of the herd means longer maintenance of cows in the herd. The average herd life is a function of annual removal and replacement percentage and will be stable until the herd's arrangement has not underwent any change.The average optimal life is obtained based on years from the number of dairy cows divided by replaced heifers in the year. Using optimal alternative strategies and removing older ones from the optimal age lead to increased profitability. Increasing optimal life leads to increased opportunity for voluntary removal and also decreases annual replacement costs regarding each cow in the year as well as increased herd production through increasing reproductive cows in higher age ranges. The optimal annual replacement rate that is the reverse of herd's optimal average age and equals the total voluntary and involuntary removal rates, was obtained as 21% in this study for the basic scenario.

REFERENCES

[1] D.P. Bersekas,2nded.,. Athena Scientific,Belmont,**2001.**
[2]V.L. Cardoso, J.R. Nogueira, J.A.M. Van Arendonk, *J. Dairy Sci*,**1999,** 82, 1449–1458.
[3]W.R. Congleton, L.W. King, *J. Dairy Sci*, **1984**,67, 661-678.
[4] J.C.M. Dekkers, Iowa State University, Iowa, USA, **2003.**
[5]G.L. Hadley, C. A.Wolf, S.B. Harsh, *J. Dairy Sci*, **2006**, 89, 2286–2296.
[6] A.M. Heikkila, *J. Dairy Sci*, **2008,** 91, 2342–2352.
[7]E.P. Houben, *J. Dairy Sci*, **1994,** 77, 2975-2993.
[8] R.A. Howard, John Wiley and Sons, New York, **1960.**
[9]H.M. Stewart, E.B.Burnside, J.W.Wilton, W.C. Pfeiffer, *J. Dairy Sci*, **1977,** 60, 602-617.
[10] A.S.Y. Kalantari,H.Mehrabani-Yeganeh, M.Moradi, A.H.Sanders, A. Devries, *J. Dairy Sci*, **2010,** 93, 2262-2270.
[11] D.A. McCullough, *J. Dairy Sci*,**1996,**79(1), 50-61.
[12] M.J. Miranda, P.L. Fackler, MIT Press, Cambridge,**2002.**
[13]P.J. Rajala-Schultz, *Acta Vet. Scand*, **2000**, 41, 185-198.
[14] G.W. Rogers, J.A.M. Van Arendonk, B.T .Mcdaniel, *J. Dairy Sci*, **1988,** 71, 3453-3462.
[15] SAS Institute, SAS users guide Statistics, Version 9.12 SAS Institute Inc, Cary North Carolina, **2001.**
[16]J.A.M. Van Arendonk, **1984,** 101, 330-340.
[17]J.A.M. Van Arendonk, A. Dijkhuizen, *Lives. Prod. Sci*, **1985,** 13, 333-349.
[18] J.A.M. Van Arendonk, *Lives. Prod. Sci*, **1986,** 14, 15-28.