Making Informed Culling Decisions

Huybert Groenendaal [1] and David T. Galligan [2]

[1] Vose Consulting US LLC, 14 Green Street, Princeton NJ 08542
Email: huybert@risk-modelling.com
www.risk-modelling.com
[2] Center of Animal Health and Productivity, New Bolton Center, University of Pennsylvania, 382 West Street Road, Kennett Square PA 19348
Email: galligan@vet.upenn.edu

Take Home Message

- The breeding and replacement policy of dairy cows greatly influences the profitability of a dairy herd. Thus, for its economic success it important that the producer makes optimal breeding and replacement decisions;
- Breeding and replacement decisions are often made in a non-programmed fashion and often based on intuition rather than through a formal economic analysis. The user-friendly model described in this paper can help dairy producers make decisions;
- The Retention Pay Off value of a cow stands for the extra profits which can be expected from keeping her, compared to replacing her with a replacement heifer. It can help dairy producers decide to keep or replace a cow.
- With a voluntary waiting period of around two months, early conception is preferred to later conception;
- The costs of later conception ranged from almost zero to $3 per additional day open;
- Allowable Breeding Space can help producers see how much more time remains in the current lactation where it is profitable to continue breeding an open cow.

Introduction

An important goal of a commercial dairy farmer is the maximization of total farm profits (Renkema and Stelwagen, 1979). Several studies have found that the breeding and replacement policy of dairy cows greatly influences the profitability of the herd (Renkema and Stelwagen, 1979; Congleton and King, 1984). For the economic success of the dairy operation, it is therefore important

to make optimal reproduction and replacement decisions (DeLorenzo et al., 1992).

Currently, most of the breeding and replacement decisions are made in a non-programmed fashion and based mostly on the intuition and experience of the producers (Lehenbauer and Oltjen, 1998). A possible way to help producers to make optimal breeding and replacement decisions is with the aid of a computer program (or Management Support Systems). In the past, several computer programs have been developed to help dairy producers make better breeding and replacement decisions (Giaever, 1966; Van Arendonk, 1985, DeLorenzo et al., 1992; Jalvingh, 1993; Kristensen, 1993; Houben, 1995). However, a problem with most of these computer programs was that they were complicated and needed high computer skills to use. Also, to our knowledge, none of the existing breeding and replacement models are directly available. As a consequence, little progress has been made at the farm level in making better culling decisions (Lehenbauer and Oltjen, 1998).

For use as a decision-supporting tool on the dairy farm, we believe a model should be simplified as much as possible without compromising the accuracy of outputs. For that reason, a spreadsheet model was constructed to support optimal replacement and breeding decisions. The model is user-friendly, in that, it allows users to easily change all input parameters under different production and economic situations on dairy farms.

This paper will describe several important concepts of optimal replacement and breeding decisions in dairy herds. It also describes some results when the computer model described above was applied to an example herd. The paper will end with several general recommendations for dairy farmers to make improved breeding and replacement decisions.

How to Determine Optimal Replacement and Breeding Decisions?

To make economically optimal replacement and breeding decisions, we have to take the following steps:

- We first have to determine what decision options we have. A producer can make the following decisions (see also Figure 1):
  1. Keep the cow;
     a. Breed the cow;
     b. Not breed the cow.
  2. Replace the cow immediately.

- The second step is to determine how much profit we expect when we make any of these choices. To do this, we have to calculate the future revenues and costs, taking into account all relevant opportunities and risks.
- The third and final step is to determine which of the options give the maximum expected profits. The option with the maximum profits is the economical optimal decision.

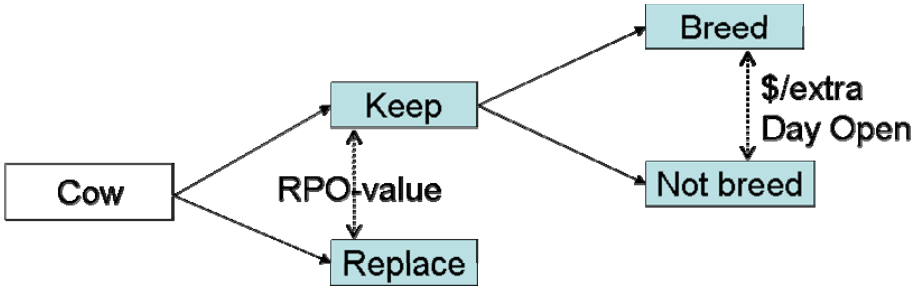

Figure 1. Schematic overview of replacement and breeding decisions.

The above two decisions can be evaluated as follows:

Keep or Replace

When a producer makes a decision to replace or keep a dairy cow, he should compare the expected future profits of the options; (1) keep this cow or (2) replace her with another animal (in this paper, we assume that this replacement animal is a pregnant heifer). We can then calculate the expected profits from keeping the current cow minus the expected profits from replacing her with another animal. This difference is called the Retention Pay Off (RPO) value (Figure 1). It is now easy to see that the higher the RPO of a cow, the more profit we expect from her. Also, when the RPO of a cow is negative, the cow should be replaced immediately (this is economically optimal). The RPO value of a cow is therefore an important parameter when making replacement decisions. A more detailed explanation of the calculations in the model is given in Groenendaal et al. (2004).

Breed or Not Breed

When a producer decides to keep an open dairy cow the next decision will be to breed the cow or not (wait with breeding or keep the cow open).

- First, we will have to determine what the *optimal time of breeding* cows is.

- Secondly, the *economic losses per extra day open* give us insight into how much loss we have if we are not able to breed the cow at this optimal time of breeding.
- Finally, it is useful for a producer to know how much longer a cow can be bred before this becomes economically unattractive. The *Allowable Breeding Space (ABS)* can be determined, which stands for the time (months) remaining in the current lactation where it is profitable to continue breeding an open cow (Figure 2). The ABS is a new measure of reproductive efficiency that integrates the rate of pregnancy with economic value. Pregnancy rate measures how quickly cows get pregnant independent of their production status. The reciprocal of pregnancy rate is the number of 21-day intervals required for the average cow to conceive. The problem with using pregnancy rate as a measure of reproductive efficiency is however that two herds can have identical pregnancy rates but can still be in very different economic states. This is because pregnancy rate does not consider which cows are pregnant (high production vs. low production cows). Thus, a herd that has a relatively low pregnancy rate, but only successfully breeds high producing animals can be better off than a herd with a higher pregnancy rate of mostly low producing animals. ABS takes into account the economic value of the reproductive efficiency.

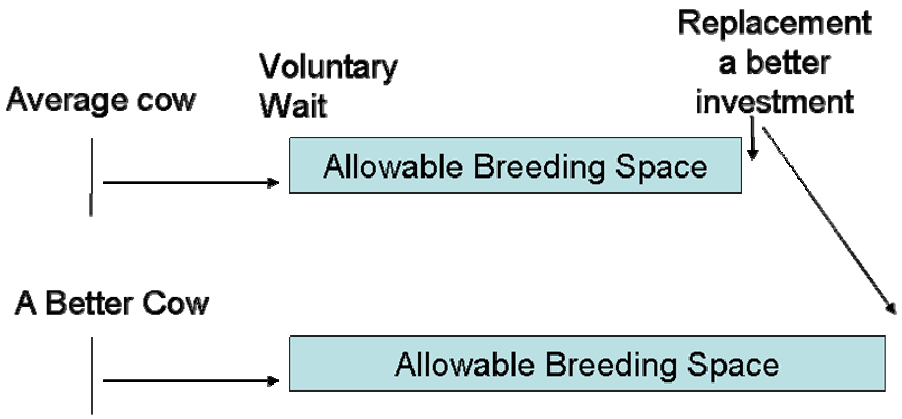

Figure 2. Schematic overview of the Allowable Breeding Space (ABS).

Example Situation

To show the use of the economic concepts described above in an existing computer model, the results of an example situation are shown below. The model used for this paper can be freely used as a decision-supporting tool for producers, extension personnel, veterinarians, and consultants. In addition,

researchers, economists, and government organizations can use the model to determine the costs of culling dairy cows in disease control programs. The model and manual are available for download at:

http://cahpwww.vet.upenn.edu/software/econcow.html.

The main input parameters of this situation are shown in table 1.

Table 1. Parameter values used for variables in the example applications of the breeding and replacement model (in $US).

	Parameter	**Value / price**	
Prices	Milk price	0.256	$ / kg
	Calf value	50	$ / calf
	Costs replacement heifer	1132	$ / heifer
	Insemination costs	12	$ / breeding
	Feed costs lactation (feeding program based on milk production)	0.20	$ / kg DMI
	Feed costs dry period	0.15	$ / kg DMI
	Price per kg of carcass weight (basis)	0.69	$ / kg
	Risk-free discount rate	5	% / year
Herd data	Average herd milk production per year	9,072	Kg
	Voluntary waiting period after calving	50	d
	Heat detection rate	40	%
	Conception rate	40	%
	Age first calving	26	Mo

The results of this model are very comparable to earlier and more complex models which are much more difficult to use.

Keep or Replace

Just to remind ourselves, the RPO value of a cow is equal to the expected profits from keeping the current cow minus the expected profits from replacing her with another animal. Thus, knowing the RPO value of a cow is useful to a producer for the following reasons:

- The RPO of a cow stands for the value of keeping the cow until the optimal time of replacement, compared to replacing her. It can therefore be seen as the total maximum amount of money that could be spent in trying to keep an animal in case of reproductive or health problems (Van Arendonk, 1985; Huirne at al., 1997). It is also equal to the costs of culling an animal in, for

example, a “test-and-cull” program against Johne’s disease (Groenendaal et al., 2002).

- When the RPO of a cow is negative, the cow should be replaced immediately because the profits expected from replacing her are higher than the expected profits from keeping her.

For cows with a 15-month (the herd average in this example) calving interval and under the 5 different production levels (as a percentage of the herd average milk production), the RPO values are shown in Figure 3.

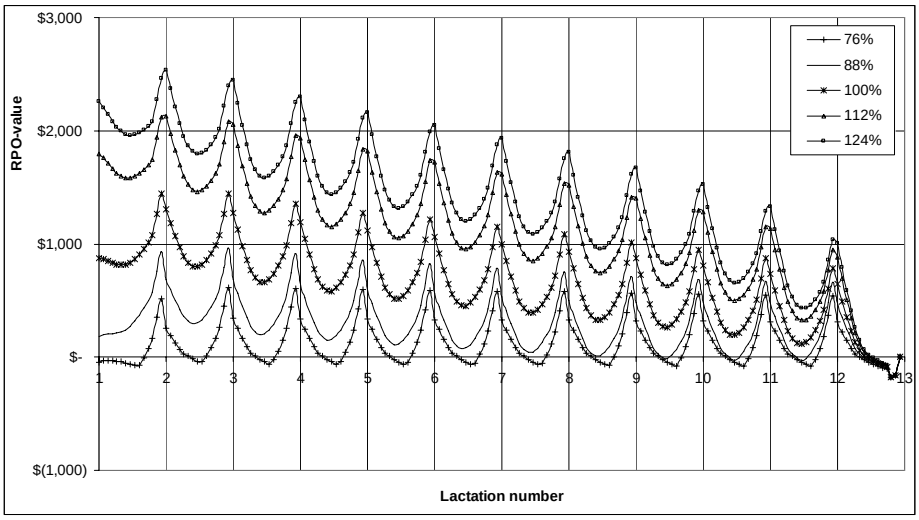

Figure 3. The Retention Pay-Off (RPO) value of cows with different milk production levels (relative to the herd average milk production) with an average 15-months calving interval (vertical lines indicate calving event; a successful breeding occurs 9 months before) (in US$).

There are four important (and intuitive) observations we can make from Figure 3:

- First, it is easy to see that cows that have a higher milk production have higher RPO values for a given reproductive efficiency (calving interval). Cows with a 124% milk production level with a 15-mo calving interval (herd average) have a maximum RPO value at the end of their first lactation (start of the second) of around US $1800. However, assuming a normal distribution around the average milk production and a standard deviation of 907 kg (2500 lb) (De Veer and Van Vleck, 1987), only ~3% of the cows have a milk production ≥124%.

- Second, the RPO value of a cow is generally the highest just before calving. For cows with a 15 months calving interval, the RPO is minimal around 7 to 9 months after calving depending on the milk production level.
- Third, the maximum RPO values across lactations for high-producing cows gradually decline from lactation 1 to 12 (expect for low producers which reach their maximum RPO value in the second lactation). After reaching the maximum, the RPO value of cows gradually declines with a higher lactation number.
- Fourth, RPO values of cows with a low production level decrease to negative values around 6 to 7 months in lactation, depending on lactation number and reproductive efficiency. This means that, at this time, the cow should be replaced. However, if the producer decides to keep the cow and successfully breeds her, her RPO value will increase again to positive values around 4 months before calving. Beyond that point, the cow should be kept again until the next time the RPO goes below zero and culling becomes the optimal decision.

Breed or Not Breed

If we decide to keep an open cow, we should evaluate whether to breed her or not. The following results were obtained.

Optimal Time of Breeding Cows. In the example situation evaluated, we found that (with a 50-day voluntary waiting period) early conception is economically more attractive than a prolonged number of days open. While some other studies suggest an economic advantage of a slightly prolonged number of days open for high-producing cows (Arbel et al., 2001), field experience suggests a voluntary wait period of around 2 months.

Costs per Extra Day Open. Because early conception is generally preferable, a producer will incur losses when conception is later. With the computer model the costs per additional day open were estimated. For the standard example situation, assuming a replacement animal is available, the costs per additional day open for a third lactation cow with five different production levels are shown in Figure 4.

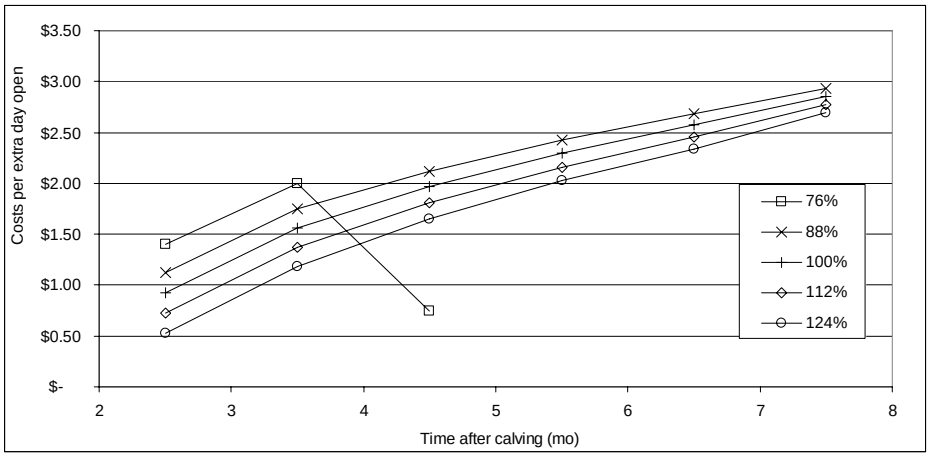

Figure 4. Costs per extra day open for third lactation cows with 5 production levels as a percentage of the herd average milk production (with replacement heifers available - with opportunity costs) (in US$).

Figure 4 shows us three important results:

- First, the costs per extra day open are going up when the time after calving gets longer; from $0.50-$1.50 per additional day open from 2 to 3 months after calving to $2.50-3.00 per additional day open from 7 to 8 months after calving.
- Second, the costs per additional day open are higher for lower-producing animals than for high producing animals. This is in agreement with Strandberg and Oltenacu (1989), who found that a longer calving interval for high-producing cows does not decrease profitability as much as for low-producing cows.
- For low producing animals (see in Figure 4 the line with a 76% production level), the costs per additional day open become zero after a few months. The reason for this is that replacement of these animals becomes the best decision, and thus breeding the animal is not the optimal decision.

The costs per extra day open also vary for animals in different lactations. Figure 5 shows the cost per extra day open for cows in three lactations (first, second, and third) with three different milk production levels.

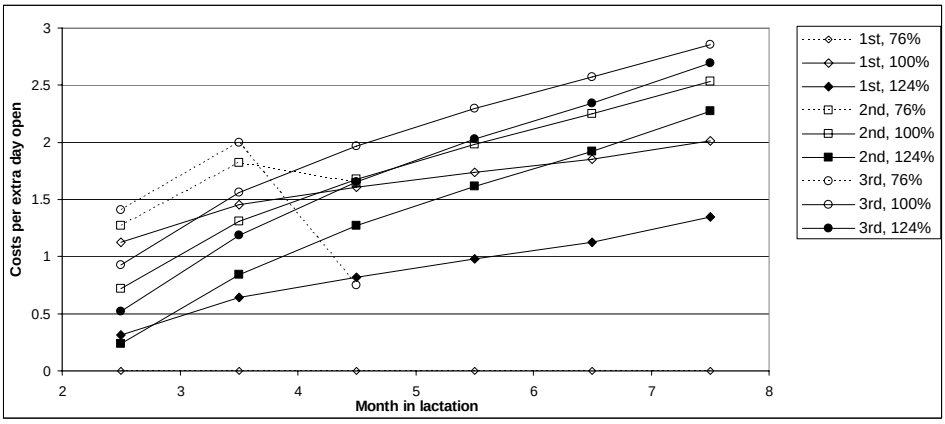

Figure 5. Costs per extra day open for first, second, and third lactation cows with a (76% level), average (100% level), or high (124% level) production level with replacement heifers available (with opportunity costs). Breeding is not optimal for a first lactation cows at the 76% production level and therefore the costs per extra day open are shown as $0 (in US$).

Figure 5 shows us two main results:

- Firstly, for all three lactations, the costs per extra day open are higher for low-producing animals than for higher producing animals (see also figure 4
- Secondly, we can see that the costs per extra day open are lower and increase at a slower rate for first lactation animals than for animals in the second and higher lactation. This effect is caused by a higher persistency of the milk production of first lactation animals than for second and higher lactation animals (Skidmore, 1990).

Allowable Breeding Space. After we know the optimal time of conception and the costs per extra day open, we still do not know how much more time (months) are remaining in the current lactation where it is profitable to continue breeding an open cow. The ABS therefore indicates how much time is left to breed an open cow (Figure 2). In Table 2, the ABS of five cows in the example herd, are shown.

Table 2. Determination of the Retention pay-off (RPO) and Allowable Breeding Space of 5 dairy cows in the example herd (in US$).

	Input parameters				Output of the model	
Cow	Lact nr.	Milk/day (kg)	Days in Milk	Days pregnant	RPO-value	ABS (months)
1	1	30	69	0	$270	6
2	6	25	13	0	$365	0
3	7	35	140	0	$104	1
4	6	35	180	0	$153	3
5	5	45	103	68	$819	6 [1]

[1] the ABS of a pregnant cow stands for the time (months) that it still would be profitable to continue breeding the cow, at the moment of her conception.

The first cow (no. 1) was assumed to be 69 days in milk with a milk production of 30 kg/d. The RPO value for her was $270, and there were 6 months left in which it would be profitable to breed her. Beyond that, it would be more attractive to keep her open and replace her at a later stage. Cow no. 5 is already pregnant, and thus the ABS has a slightly different meaning. For a pregnant cow, the ABS stands for the time (months) that it would have been profitable to continue breeding the cow, at the moment of her conception. A herd manager desires to maximize his ABS for open and pregnant cows. The ABS on open cows represents potential opportunity while the ABS on pregnant cows represents captured opportunity.

Conclusions

- The Retential Pay Off (RPO) value of a cow stands for the value of keeping the cow until the optimal time of replacement, compared to replacing her. It can be used to make optimal replacement decisions but it also stands for the costs of culling an animal in, for example, a “test-and-cull” program against a disease such as Johne’s disease.
- When the RPO of a cow is negative, the cow should be replaced immediately because the profits expected from replacing her are higher than the expected profits from keeping her.
- From the results of this study, it was concluded that early conception is most profitable. While other studies suggested an advantage of a prolonged days open period for high-producing cows (Arbel et al., 2001), we only found that the cost per additional day open for high-producing cows was fairly low.

- Using the input parameters shown in Table 1, the costs per additional day open varied between $0 and $3. The following four factors greatly influence the costs per additional day open:
    - Month in lactation: The costs per additional day open are higher the further an animal is in its lactation;
    - Availability of replacement heifers: when a replacement heifer is not immediately available, the costs per additional day open are lower and insemination remains optimal for a longer time after calving;
    - Lactation number: in general, the costs per day open are higher for animals in higher lactations
    - Relative milk production: The costs per day open are lower for high producing animals, than for low producing animals.
- The Allowable Breeding Space (ABS) stands for the time (months) remaining in the current lactation where it is profitable to continue breeding an open cow.

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