Ranking Dairy Cows for Optimal Breeding Decisions

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Summary

This paper discusses when to start and stop breeding cows in their lactation. First, a review of the literature on the optimal voluntary waiting period (when to start breeding cows) shows that there is not much consensus on how long the economically optimal voluntary waiting period is. Secondly, the paper then describes a computer program that calculates the insemination value (IN$) for cows in a herd to support breeding decisions. The insemination value is the expected profit from breeding the cow compared to not breeding her when a breeding opportunity arises. Cows with an insemination value less than $0 should not be bred. Early in lactation this implies that the voluntary waiting period for cows with an insemination value less than $0 should be extended. The program showed that high producing persistent cows should have an extended voluntary waiting period. On the other hand, extending the voluntary waiting period for low producing cows could be costly. Insemination values are illustrated for the cows at the University of Florida Dairy Research Unit. The program currently functions as an add-on to PCDART and will be available to dairy producers to assist them with breeding decisions.

Introduction

Dairy producers are constantly challenged with making optimal breeding decisions. Optimal breeding decisions are those that maximize the profitability obtained with the current cow and herd replacements in a slot in the herd. This paper only discusses when to start breeding cows after calving and when to stop breeding cows that have failed to conceive. It also discusses the value of an insemination to indicate how important the correct breed or do-not-breed decision is. Other aspects of optimal breeding decisions, such as the best breed technique or what semen to use, are not discussed.

When to start breeding cows: voluntary waiting period

Historically, the optimum calving interval has been 12 to 13 months. This means that cows should get pregnant between 3 and 4 months after calving. Unfortunately, there is no guarantee that a cow gets pregnant if she is bred. Therefore, the goal was to breed cows as soon as possible after calving when the involution of the uterus and return to cyclicity were more or less completed (VanDemark and Salisbury, 1950). The voluntary waiting period (VWP) is defined as the time from calving to the start of the breeding period. Britt (1975) reviewed the literature over 30 years ago and found that conception rates of cows with a first AI at various voluntary waiting periods increased at a decreasing rate until they reached a peak in conception at about 80 days (Stevenson, 2004). Although early-bred cows needed more breedings per pregnancy, calving intervals could be shortened by maintaining an average voluntary waiting periods of 50 to 60 days (Stevenson, 2004). This means that the voluntary waiting periods was even shorter, because not all cows are in estrus at the start of the breeding period.

Programmed breeding options such as PreSynch (2 x $PGF_{2\alpha}$, 14 days apart) and Ovsynch (GnRH on day 0, $PGF_{2\alpha}$ on day 7, GnRH on day 9, timed-AI on day 10) allow dairy producers to schedule the time of a cow's first breeding opportunity. Milk production per cow keeps increasing year after year and the use of BST has let to more persistent lactations. Days in milk at peak yield is also increasing. First-parity cows that conceive early may not reach their production potential in the second lactation because they have not had adequate time in the first lactation to grow and restore body condition (Olson, 2004). As a result of these considerations and others, there is much discussion about the optimal voluntary waiting periods. Many reproductive specialists have recommended a 70-day voluntary waiting period for first AI after a PreSynch + Ovsynch program (Prentice, 2006). Record analysis by USDA-AIPL showed a slight increase in time to first AI between 1995 and 2002 (Miller et al., 2005). Fifty percent of the herds have 10% of their cows inseminated by 55 days after calving.

It is questionable if a programmed breeding protocol should be supplemented by breeding based on observed estrus prior to the first timed-AI. Breeding based on observed estrus may reduce the conception rate of the timed-AI because a greater fraction of cows submitted to AI may be not cycling. Even with a reduced conception rate to first timed-AI, breeding cows based on estrus early in lactation may improve the total number of cows that are pregnant at 150 days in milk because breeding starts earlier in lactation. Only cows not seen in estrus would enroll in the first programmed breeding protocol. This might reduce drug costs. On the other hand, the option to breed based on observed estrus might increase labor needs and costs. Getting cows pregnant too early may affect milk production and force producers to dry off some still high producing cows. So there are arguments in favor and against breeding based on estrus detection before the first timed-AI. Which scenario is economically most profitable depends on the situation of the herd and general recommendations should not be given (Tenhagen et al., 2004).

Although some studies have shown that generally calving intervals of 12 to 13 months are probably still economically optimal (Galton, 1997), several other studies have shown that there are exceptions to this rule. Longer calving intervals may be obtained by longer voluntary waiting periods. Some of the most quoted papers that looked at optimal voluntary waiting periods will now be discussed.

Studies with various voluntary waiting periods: literature review

Preliminary data from a Danish study with two small herds (Bertilsson et al., 1997) did not show any significant differences in reproductive efficiency in herds managed for a 12, 15, or 18 month calving interval (Table 1). However, the longer voluntary waiting period (VWP, 140 days) in herd 1 numerically showed a better reproductive efficiency. No programmed breeding protocol was used in this study. The small number of cows hampers the ability to observe significant differences.

Table 1. Reproductive efficiency of three different voluntary waiting periods in two herds. Cows are only bred on observed estrus (Bertilsson et al., 1997).

	Herd 1		Herd 2	
VWP (days)	50	140	50	230
No. cows	45	45	24	24
Conception rate at first AI (%)	32	50	52	52
% Pregnant	81	93	100	100

There is some evidence that the Ovsynch program works better when first AI occurs later in lactation. Research in Wisconsin and elsewhere showed that pregnancy rates per AI after the Ovsynch protocol was 26% if first AI occurred between 60 to 75 days after calving, but 43.4% if it occurred after 75 days after calving (Pursely et al., 1997).

A German study (Tenhagen et al., 2003) varied the voluntary waiting period to first timed-AI in three groups: 53-59 days, 73-81 days, and 94-102 days. They did this for low, average, and high producers relative to their parity average. Both first parity and older cows were studied. When the Ovsynch protocol was used for the three groups with a voluntary waiting period of 73-81 days, pregnancy rates at first timed AI tended to decrease as milk production increased (Table 2; 34.5%, 28.7%, and 28.2%, respectively). In the low producing group, pregnancy rates at first AI increased from 14.4% to 34.5% when the voluntary waiting period increased from 53-59 to 73-81 days. In the high producing group, pregnancy rates at first AI increased from 28.2% to 41.4% when the voluntary waiting period increased from 73-81 to 94-102 days. Therefore, pregnancy rates at first timed AI are not impaired by high milk production when first timed AI takes place later in lactation in higher producing cows. Although the voluntary waiting period was extended by 20 days, the percentage of cows pregnant at 200 days in milk was similar for the low and average producing cows. They economic implications of these results are not completely clear, however.

Table 2. Reproductive efficiency of three different voluntary waiting periods for low, average, and high producing cows with the Ovsynch protocol (Tenhagen et al., 2003).

	Low producers		Average producers		High producers	
VWP (days)	53-59	73-81	73-81	73-81	73-81	94-102
No. cows	153	148	262	230	142	128
% pregnant at timed AI	14.4	34.5	34.0	28.7	28.2	41.4
% pregnant at 200 DIM	78.4	76.4	80.2	80.4	69.7	71.9
Days open	115	108	114	115	113	123

Cornell University compared the reproductive performance of cows with a voluntary waiting period of 60 or 150 days that were treated with BST (Van Amburgh et al., 1997). Rates of estrus detection, conception and pregnancy were not different. Although cows with the extended voluntary waiting period spend more time later in lactation, average daily milk yield during the entire lactation was similar (70 vs. 69 lbs). Their economic comparison of calving intervals of 13.2 months vs. 18 months, including use of BST, showed that the extended calving interval was $274 / cow / year more profitable. The majority of this profitability was explained by increased milk income over feed cost during a cow's productive life. These authors concluded that extending the calving interval to 16.5 months might be economically warranted, especially in high producing herds. This would push the voluntary waiting period to 150 days. Especially first parity cows could benefit from an extended calving interval

Another large study evaluated voluntary waiting periods of 60 and 165 days, with and without the BST in 26 herds (McGrath et al., 2003). Delayed breeding resulted in more days dry, longer calving intervals, and similar percentages of cows pregnant. The authors later concluded that delayed breeding increased net income over feed cost and BST cost per cow per year in first parity cows but not in older cows (Lormore, 2003).

In Israel, the voluntary waiting period was delayed in first parity cows from 90 to 150 days and in older cows from 60 to 120 days (Arbel et al., 2001). Conception rates for both voluntary waiting periods were similar in each parity group, but first parity cows had greater conception rates (Table 3). Milk yields per day, measured as energy corrected milk, were 1.7 lbs higher in first parity cows but the same in older cows. Based on the first year in which the voluntary waiting period was delayed, profit per day was increased by $0.19 in first parity cows and $0.12 in older cows. Results in the second year were also in favor of the delayed voluntary waiting period group. These authors also concluded that first parity and older cows with extended lactation were more profitable. Again the advantage for the first parity cows was greater because of their more persistent lactation curves.

Table 3. Effect of extended voluntary waiting period (VWP) on reproductive efficiency, milk yield and profit (Arbel et al., 2001).

	First parity			Older cows	
VWP (days)	90	150		60	120
No. cows	133	131		215	271
Conception rate (%)	40.3	43.5		36.6	38.7
Days to first AI	93	154		71	124
Days open	128	189		110	160
Milk yield/lactation (lbs)	28,151	31,669		24,767	29,121
Milk yield/day (lbs)	61.1	62.8		72.3	72.8
Profit ($/cow/day)	3.42	3.61		4.34	4.46

A Danish study concluded, however, that extending the voluntary waiting period by an additional 70 days was not profitable (Sørensen and Østergaard, 2003). Herd profitability was reduced by 1 to 4% and the reduction was the greatest in herds with poor reproductive efficiency. These authors concluded that their economic analysis was sounder than in the study by Arbel and others in Israel. The Israeli study did not properly account cow culling and replacement costs. If herd replacement is included, then the effect of lactation persistency and number of days dry per year will be less important then when only consecutive lactations for single cows are considered.

Economic analyses with computer programs that optimize breeding and culling decisions also revealed that high producing and persistent cows could have extended voluntary waiting periods and should be rebred longer before being culled (Dekker et al., 1998; Rajala-Schultz et al., 2000). Such programs have also shown that seasonality in performance and prices has a significant effect on optimal breeding decisions.

Conclusions about optimal voluntary waiting periods from the literature

Longer voluntary waiting periods past 100 days did not improve conception rates or other reproductive measures. Conception rates earlier in lactation might be compromised because cows are in a more negative energy balance. Longer voluntary waiting period may increase milk yield per cow per year and reduce total days open, but the length of the dry period may also be increased. Calving intervals greater than 15 months (longer voluntary waiting period) were economically beneficial in older studies, but not necessarily in more recent studies. There is generally agreement that first parity cows could have a longer voluntary waiting period than older cows, especially if they are higher producing. Many of the economic analysis do not consider all relevant risks, revenues and costs. The optimal voluntary waiting period is herd (and cow) dependent.

When to stop breeding cows

Just like there is a start of the breeding period after calving, there is also an end of the eligible breeding period after calving for cows that failed to conceive. When to stop breeding cows depends in general on the same factors as when to start breeding cows. The rebreeding policy is also highly associated with the culling and replacement policy of the herd. It is difficult to give general guidelines. Not only are herds different, but optimal rebreeding decisions are cow-dependent (Van Arendonk, 1988). Minimum factors to consider are level of production, parity, and days open. Most dairy producers will do this. High producing cows that are more persistent could be rebred much longer before they are put on the do-not-breed list. A Canadian study, for example, concluded that in herds with low fertility, rebreeding up to 364 days after calving was optimal (Plaizier et al., 1997).

Because it is difficult to give general guidelines, it is more useful to be able to calculate optimal breeding and replacement decisions for individual cows under herd-specific conditions. A computer program that can do this is discussed in the following Florida study.

Florida Study: insemination value (IN$) and retention pay-off (RPO$)

The ideal guide for breeding decisions advises if a cow should be kept and bred, kept but not bred, or culled (and replaced with a heifer). The ideal breeding guide should also rank cows based on the value of the optimal decision compared to another (non-optimal) decision. Decisions to inseminate and replace cows should be based on expected future income or cash flows (Van Arendonk, 1988). In other words, the goal of optimal breeding decisions is to maximize profit per slot per year. A slot is a place for a cow on the dairy farm. The number of available slots is limited, either by a constraint such as the number of stalls, parlor capacity, or for example available labor.

The insemination value (IN$) is the extra profit expected from breeding the cow now compared to not breeding the cow now, but making optimal breeding and replacement decisions in the future. This includes the option that the cow should be (re)bred at the next available breeding option and later. A slightly differently formulated insemination value was used earlier in Florida (DeLorenzo and Thomas, 1996).

Although computer programs that optimize breeding and replacement decisions have been around for over 20 years, our current work aims to improve upon these programs. Improvements are possible in the frequency of decision making (weekly decisions vs. monthly in older programs) and more accurate predictions of individual cow performance. This means better future cash flow predictions and ultimately better decisions.

Future cash flows for the cow currently in the slot are determined from all revenues and costs in the remainder of the lactation, as well as revenues and costs in the following lactations (if any), and revenues and costs of her future replacement heifers. Over time, every cow will be culled and replaced with a replacement heifer. Optimal breeding decisions depend on culling decisions and vice versa. If open cows are bred they may or may not get pregnant which affects their future risk of culling. The predicted future cash flow is therefore an average of all possible future cash flows of the current cow and her potential replacement heifers, weighted by the probability that an event (breeding, culling) happens. Replacement heifers will be replaced by other heifers as well. Because cash flows are unequal over time, discounting needs to be applied to make the value of the sums of the cash flows today, i.e. their present values, comparable. Discounting also makes accurate estimates of revenues and costs farther in the future less important. Probability calculations show that after several years in the future the expected cash flows are independent of the breeding and culling decision for a slot made today. Consequently, to make the optimal breeding and culling decision of the cow currently in the slot, we need to project future cash flows several years into the future, but not indefinitely.

Once the present values of the future cash flows of both the decision to breed the cow and the decision to not breed the cow are calculated, the optimal decision is simply the one with the highest present value. The difference in both present values is the insemination value (IN$). If the insemination value is less than $0, then the cow should not be bred. Cows can be ranked by insemination value. The cow with the highest insemination value is the most important one to breed if a breeding opportunity exists.

Optimal culling decisions are based on the retention pay-off (RPO$). The RPO$ is the extra profit from keeping the current cow in the herd until her optimal time of replacement, considering the risk of premature culling, compared to immediate replacement. When the RPO$ is greater than $0, the cow currently in the slot should be kept, at least until the next decision moment. If she were culled today, the opportunity cost equals her RPO$. When the RPO$ less than $0, the cow should be culled and replaced with a heifer.

Florida Study: implementation of computer program

Accurate estimation of future cash flows involves prediction of the milk yield in the remainder of the lactation, risk of pregnancy and abortion, risk of death and other risks that cause premature culling, as well as future prices. It also involves optimization of future breeding and culling decisions, based on predicted performance, risk and prices, so that future cash flows are truly as maximal as possible. The computer program described in this paper can do both: 1) it predicts future performance; 2) it optimizes breeding and replacement decisions (based on the dynamic programming technique).

Calculation of the insemination value and RPO$ for each cow in the herd is done by a novel 2-step process. This 2-step process allows for very cow-specific predictions of future cash flows because the performance in the current lactation can be predicted with a lot of detail, much more than was possible in the past. The 2-step process is further described in another paper (De Vries, 2006). Table 4 lists the types of input data and their sources that help calculate very cow-specific insemination values.

Table 4. Herd and cow inputs for the computer program to calculate the insemination value and RPO$.

Herd inputs:[1]	Cow inputs:[2]
• Lactation curves	• Lactation number
• Days dry	• Days in milk
• Risk of premature culling	• Testday milk yields
• Voluntary waiting period	• Estimated relative producing ability
• Risk of service, conception, abortion	• Reproductive status (open, bred, pregnant)
• Body weights	• Days since last breeding or estrus
• Prices (milk, feed, heifers, cows, calves)	
• Discount rate	

[1] User-defined: data entered into spreadsheet.
[2] From a report created by PCDART or other dairy management program.

The effects of days in milk, parity, level of milk yield, persistency, and conception rate on insemination value were evaluated for an example herd. The computer program uses many inputs to best mimic the performance of cows in the herd and prices of heifers, milk, calves, feed etc. Some key inputs for he example herd are in Table 5. You can find more details about how cow performance is predicted in a paper earlier this year (De Vries, 2006). The data used in this paper are slightly different, however. The minimum voluntary waiting period was set at two weeks. The computer program then decided what the optimal time of first breeding was for different types of cows.

Table 5. Key inputs for the computer program to evaluate the effects of days in milk, parity, level of milk yield, persistency and conception rate on insemination value (IN$).

Herd ME milk	23,000 lbs	Heifer price	$1800
Service rate	maximum 50%	Cull price	$0.46 / lbs
Conception rate	maximum 35%	Milk price	$0.17 / lbs
Minimum VWP	14 days	Feed cost, lact.	$0.11 / lbs DM
Breeding cost	$15	Feed cost, dry	$0.07 / lbs DM

The shape and level of lactation curves have a major effect on the insemination value. For the analyses with the example herd, we used lactation curves for first, second and greater lactations calculated by the method of Best Prediction based on 23,000 pounds of herd average ME milk. Figure 1 shows the lactation curves for first, second, third lactations without test day observations.

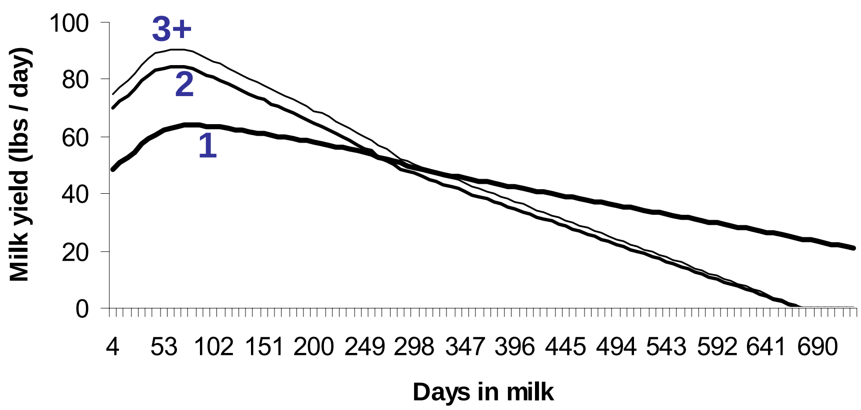


Figure 1. Lactation curves calculated by Best Prediction (first 365 days) based on 23,000 lbs herd average ME milk for Holsteins for first, second, and third and greater parities. The curves were linearly extrapolated from 365 to 730 days.

Service rates and conception rates also have major effects on the insemination value. The service rate is defined as the number of cows that could be bred if we wanted to, divided by the number of cows that are eligible to be bred. In herds with only heat detection, this would be similar to the heat detection rate. Figure 2 shows the assumptions for this paper. Cows had a breeding opportunity every 3 weeks.

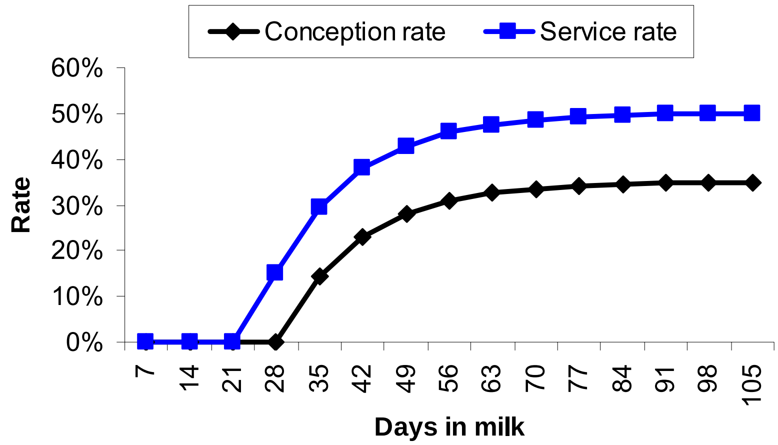


Figure 2. Service rate and conception rate by days in milk for the example herd.

Florida Study: effects of parity, milk yield, persistency, and conception rate on insemination values

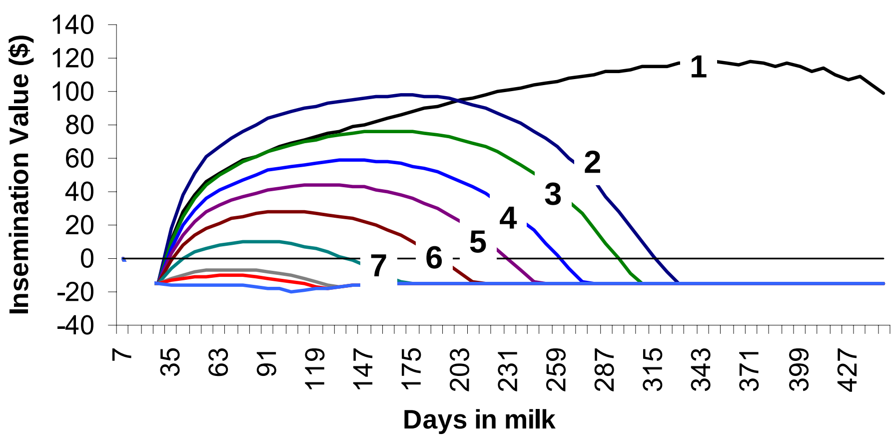


Figure 3. Insemination values for average cows in parities 1 through 10 by days in milk.

Insemination values for average cows in parities one through ten by days in milk are shown in Figure 3. The insemination value rises to a maximum and then declines again. Negative insemination values imply that the average cow should not be bred at that stage of lactation. The insemination value for first parity cows reaches a peak much later in lactation. This is a result of a more persistent lactation curve. Insemination values typically decrease with greater parity. This is primarily caused by a greater risk of involuntary culling for older cows. Average cows in parities eight to ten never have positive insemination value. These cows should not be bred but are in their terminal lactation. The voluntary waiting period for cows in parity one to five was only 35 days for the example herd. For parities six and seven it was 42 and 49 days.

The level of milk production has a significant effect on the insemination value, as shown in Figure 4. These five cows were in their first parity and had five different levels of milk production; +20, +10, 0, -10, and -20 lbs/cow/day compared to the average curve in Figure 1. Lower producing cows (-20 and -10 lbs) had greater insemination values earlier in lactation, but these values were lower later in lactation. These cows have less time to get pregnant in their lactation before they should be culled. Therefore it is important to get them pregnant early in lactation. The insemination value of the highest producing cows (+20 lbs) gradually increased, but did not get positive until day 140. This high producing, first parity cow had an optimal voluntary waiting period of 140 days. The figure shows that higher producing cows have more time to get pregnant and also should not be dried off too early.

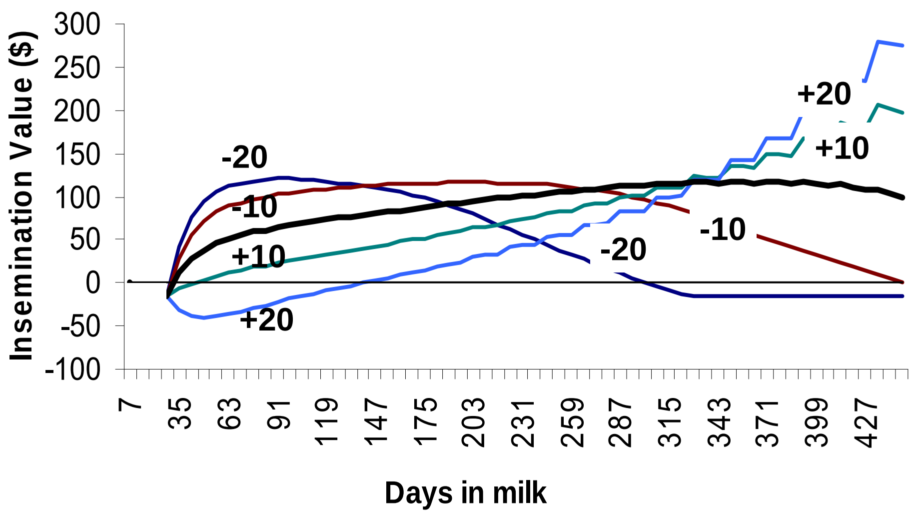


Figure 4. Insemination values for cows in the first parity for five different levels of milk production: -20, -10, 0, +10, and +20 lbs/cow/day.

Longer voluntary waiting periods than optimal can be costly, especially for lower producing cows. Waiting 100 days past the optimal VWP could cost more than $200 per cow for cows that produced 10 lbs/day less than the average cow. This is about $2 per extra day open. It is well known that cost per day open increases later in lactation (> 200 days in milk), but it is clear that the cost can be substantial even early in lactation by delaying first breeding for low producing cows.

An increase of 50% in conception rates decreased the insemination values in higher producing cows, but increased the insemination values in lower producing cows early in lactation. The decrease in higher producing cows is caused by a greater probability that the cow will still get pregnant not much later in lactation. The increase in lower producing cows is caused by a greater probability that the cow gets pregnant at all before the needs to be replaced. In general, increased reproductive efficiency resulted in a lower insemination value early in lactation, but a greater insemination value later in lactation.

Increased persistency also extended the voluntary waiting period in higher producing cows, but not in lower producing cows. In general, however, increased persistency lowered the insemination value early in lactation. This is in agreement with earlier findings (Dekkers et al., 1998).

The results above show that the insemination value and voluntary waiting period are not the same for all cows. Although for the example herd a short voluntary waiting period was optimal for many cows, the voluntary waiting period can be longer (> 100 days) when cows have relatively greater milk production, are more persistent, or have a better chance of getting pregnant.

Insemination values for the UF/IFAS Dairy Research Unit

Individual cows have their own optimal voluntary waiting period and insemination values. It is therefore useful to be able to calculate the insemination value for each cow in each herd taking into consideration the herd-specific performance and prices, and also each cow's own predicted performance. To illustrate the computer program for use in individual dairy herds, the insemination values and RPO$ were calculated for the 596 cows at the UF/IFAS Dairy Research Unit (DRU) located in Hague, Florida, on February 14, 2006.

The same inputs were used as above in the computer program for Florida. Actual data for the DRU may be different. The Best Prediction program was used to predict cow-specific lactation curves for the remainder of the lactation based on test-day milk yields observed earlier in lactation. This is part of the novel 2-step process that helps better predict individual cow performances. Figure 5 shows the 17 cows with greatest insemination value together with some of their characteristics. The RPO$ is also shown.

The greatest insemination value (IN$) on February 14, 2006, was $198. Most cows in Figure 5 are better producing cows that are open or bred (but not known to be pregnant) later in lactation. This is in agreement with the general conclusions from Figure 4. All 17 cows have RPO$ that are substantially greater than $0. Cows with a negative RPO$ also have negative insemination values: cow that should be culled immediately should snot be bred.

University of Florida Dairy Research Herd									
Sorted by Insemination Value (IN$), February 14, 2006									
Index	DIM	Lact#	LastCalv	DIM_Tst	LastBredMDY	Milk	STATUS	IN$	RPO$
4709	627	1	5/28/04	611	10/5/05	62.8	OPEN	198	596
4735	217	2	7/12/05	201	1/14/06	97.5	BRED	198	1014
4706	651	1	5/4/04	635	9/27/05	62.3	OPEN	188	344
4671	272	2	5/18/05	256	1/20/06	77.8	BRED	183	554
4679	146	2	9/21/05	130	1/13/06	128	BRED	177	1628
4562	177	2	8/21/05	161	1/18/06	102	BRED	173	1100
4770	193	2	8/5/05	177	1/5/06	89	OPEN	168	571
4703	223	2	7/6/05	207	1/27/06	98.5	BRED	163	696
4673	182	2	8/16/05	166	2/9/06	99.8	BRED	161	858
4462	351	2	2/28/05	335	1/4/06	55.7	OPEN	159	132
4420	480	2	10/22/04	464	10/27/05	64.2	PREG	152	1097
4232	156	4	9/11/05	140	1/27/06	85	BRED	148	783
4451	211	2	7/18/05	195	1/4/06	87	OPEN	148	382
4608	146	2	9/21/05	130	1/15/06	96.2	BRED	148	944
4659	181	2	8/17/05	165	2/3/06	82.9	BRED	147	612
4723	156	2	9/11/05	140	1/17/06	89.6	BRED	146	701
4727	147	2	9/20/05	131	2/9/06	93.6	BRED	146	792

Figure 5. Insemination values (IN$), RPO$ and other characteristics of the 17 cows with the greatest insemination value at the University of Florida Dairy Research Unit on February 14, 2006.

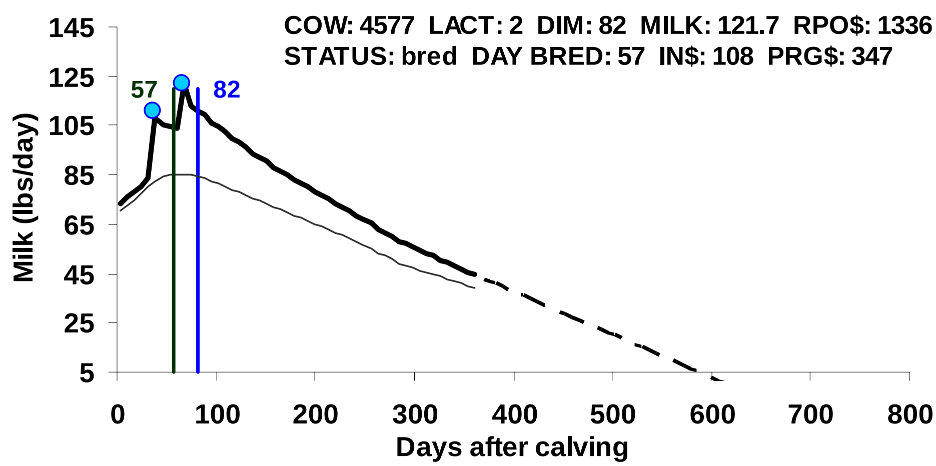
Figure 6 shows the test-day history of the two arbitrary cows at the DRU. Both cows are bred but unknown to be pregnant. Notice how the predicted lactation curve for the remainder of the lactation is updated by the test day yields. Cow A is an above-average producer with an insemination value of $108 if she was found open and eligible to be bred later that week. Cow B is an older, low producing cow. Her RPO$ of -$26 indicates that she should be culled, even though she might be pregnant. She also has an insemination value of -$15. If this cow was found open and showed estrus later this week, she should not be bred. The scatter plot in Figure 7 shows the insemination values of all 596 cows by days in milk and pregnancy status.

Other considerations

The key to a useful insemination value and RPO$ is an accurate prediction of a cow's discounted future cash flows. Especially for decisions on the optimal voluntary waiting period, it is important to be able to estimate milk yield and persistency early in lactation.

Several potentially valuable factors are not yet included in the current version of the insemination value and RPO$ calculation. The effects of a difficult calving or health problems such as metabolic diseases, mastitis or lameness are not directly considered. Problems that affect the probability of conception are currently not accounted for. Problems that reduce milk production are automatically accounted for through lower testday milk yields. The inclusion of health problems is therefore thought to have a limited effect on the insemination value and RPO$.

A



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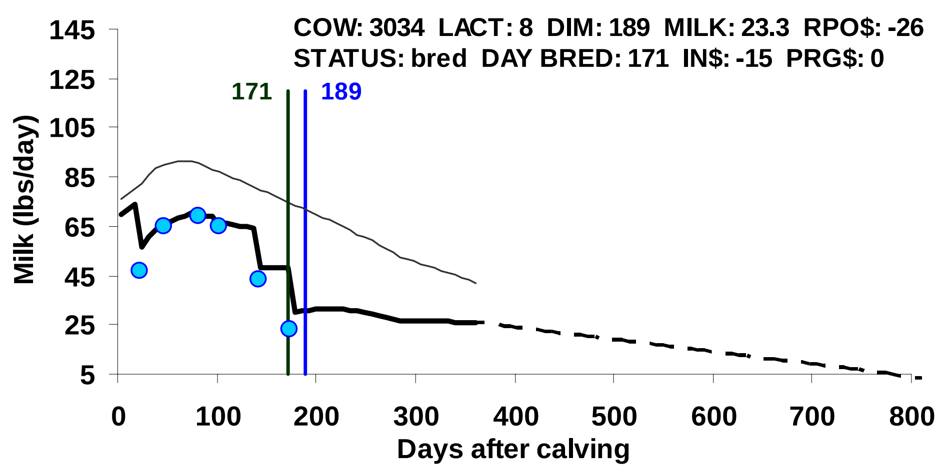

Figure 6. Test day history for two cows and their insemination values (IN$). The left vertical bar indicates last day of breeding. The right vertical bar indicates days after calving on February 14, 2006. The thin lactation curve is for the average herd mate.

The insemination value and RPO$ calculations assumes that there are no limiting constraints. A limiting constraint is for example a limited supply of heifers, parlor capacity, or milk quota. Overcrowding that affects cow performance is also an example of a limiting constraint. A breeding or culling decisions for one cow may affects the decisions for other cows. The effect of such limiting constraints on insemination values and RPO$ and ranking of cows is not well studied but probably small.

Seasonality in performance (milk production, reproduction) or prices is not included in the RPO$ for the DRU as shown above. The computer program can account for seasonality in performance and prices, but the challenge will be to estimate this seasonality accurately on any dairy farm. Seasonality does affect the insemination value and RPO$, but the effect on the ranking of cows is minimal.

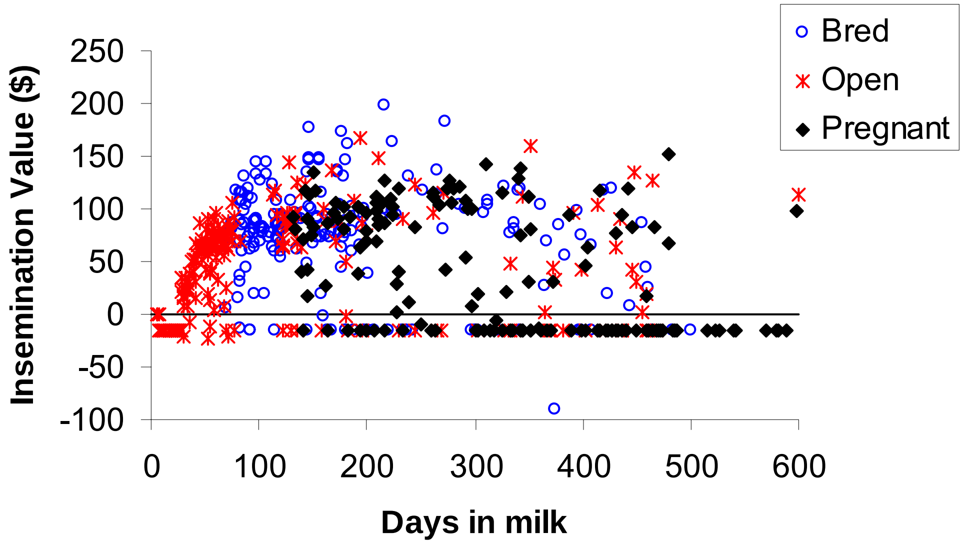

Figure 7. Scatter plot of insemination values for 596 cows in the University of Florida Dairy Research Herd on February 14, 2006.

The insemination value is the result of comparing two discounted future cash flows that result from the decision to breed or not breed the cow. This principle can also be used to support other decisions. For example, the value of a pregnancy can be calculated by comparing the discounted future cash flows of a pregnant cow and an open cow; their only difference is the pregnancy status, everything else is equal. The decision when to dry off a cow could also be supported this way.

Practical implementation

The computer program that manages the insemination value and RPO$ calculations has been developed in Microsoft Excel and C++. The procedure starts with running a predetermined user report in PCDART that saves the necessary cow data such as index, test day data, and reproductive data into a CSV-type file. CSV files can be read into Excel.

Macros in Excel automate the calculations. The macros read the CSV file, run the Best Prediction program to obtain predicted milk yields in the remainder of the lactation, run the program that calculates the insemination values and RPO$ for each cow, and finally presents the results in Excel and saves the list with the insemination values and RPO$ (Figure 8). The whole procedure takes about 6 minutes for the 596 cows at the DRU. Most of that time is used by the Best Prediction program to predict milk yields for the remainder of the lactation for each cow. The procedure could be shortened if the insemination values were only calculated for open and bred cows that may be candidates for delayed breeding or not breeding once a breeding opportunity arises. Check the UF/IFAS Dairy Extension website at http://dairy.ifas.ufl.edu for more news about the availability of this computer program.

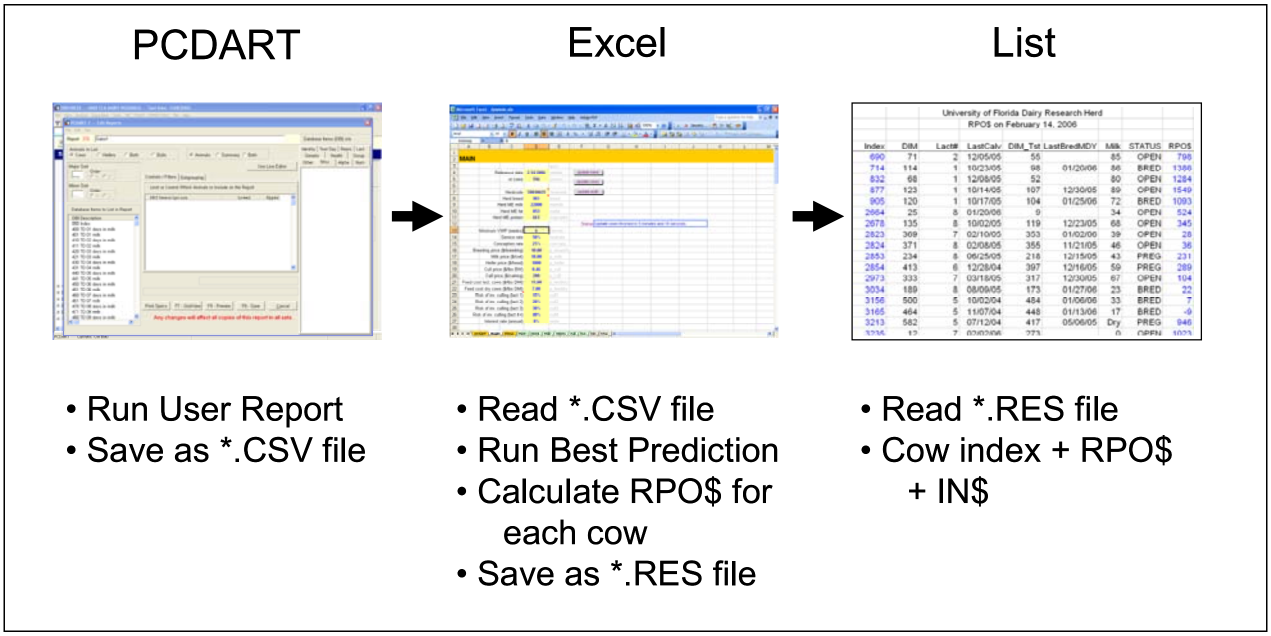

Figure 8. Procedure to obtain the insemination value (IN$) and RPO$ for cows in a herd. The procedure starts with running a report in PCDART and ends with the presentation of a list of cows with their IN$ and RPO$. The steps in Excel are automated by macros. The computer program could work with any dairy management program.

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Notes