Cash Flows of Instituting Reproductive Programs: Cost vs Reward

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Abstract

Economic returns associated with improved reproductive performance in dairy herds depend upon a wide variety of factors, including initial level of reproductive performance, future value of milk and of the calves produced, cash cost of replacement heifers, and many other factors. A variety of synchronization programs have been developed that may help improve the overall pregnancy rate (PR) of the herd, but the profitability of each program varies. A spreadsheet model was designed to compare the potential profitability of an improved estrus-detection program, an estrus-detection program combined with presynchronization and a single timed insemination, and a program relying completely upon timed insemination. Each of these scenarios was compared to a baseline program based upon estrus-detection and AI. The baseline herd was designed to have an estrus-detection risk and conception risk of approximately 50% and 31%, respectively, consistent with herds at or slightly above average reproductive performance in the US. Each of the modeled scenarios predicted better future returns than the initial baseline program, but the two involving timed AI also incurred substantial costs upfront. Adoption of either of these programs carries significant potential risk if not properly implemented and managed. Poor compliance to either timed AI program dramatically decreases both the resulting PR and the predicted economic returns. Dairies that implement programs such as these should work diligently to ensure that compliance levels consistently exceed 90% in order to maximize the profitability of either approach.

Résumé

Les retombées économiques d'une amélioration de la performance en reproduction dans les troupeaux laitiers dépendent de plusieurs facteurs incluant entre autres le niveau initial de performance reproductive, la valeur anticipée du lait et des veaux produits et le coût monétaire des taures de remplacement. Plusieurs programmes de synchronisation ont été développés afin d'améliorer le taux de gestation (TG) dans un troupeau mais le niveau de profitabilité de chaque programme n'est certes pas la même. Un modèle a été conçu avec un chiffrier pour comparer la profitabilité attendue d'un programme de détection de l'œstrus amélioré, d'un programme de détection de l'œstrus combiné avec présynchronisation et une simple insémination sur rendez-vous et d'un programme basée uniquement sur des inséminations sur rendez-vous. Ces trois programmes ont été comparés à un programme de référence basé sur la détection de l'œstrus et l'insémination artificielle (IA). Dans le programme de référence, les risques étaient de 50% pour la détection de l'œstrus et de 31% pour la conception, valeurs que l'on retrouve dans les troupeaux américains dont la performance de reproduction est moyenne ou juste au-dessus de la moyenne. Chacun des trois programmes envisagés a permis d'excéder les retombées économiques prévues par le programme de référence. Toutefois, les deux programmes avec IA sur rendez-vous comprenaient aussi des coûts de départ importants. Le choix de l'un de ces deux programmes comporte des risques potentiels importants si les programmes ne sont pas bien mis en œuvre et gérés. Ne pas respecter l'un ou l'autre des programmes avec IA sur rendez-vous décroit les retombées économiques prévues et le TG résultant. Les fermes laitières qui adoptent de tels programmes devront travailler avec diligence afin de s'assurer que le niveau de respect dépasse couramment les 90% pour maximiser la profitabilité de l'une ou l'autre de ces deux approches.

Introduction

Poor reproductive management and performance can be a significant source of economic loss affecting dairies. One of the primary drivers behind dairy herd profitability is the amount of milk produced per cow per day. Reproductive inefficiency results in decreased profitability through a variety of ways, but the largest impact is by its influence on the herd's distribution of days in milk (DIM), thus affecting the milk produced per cow per day of productive life. Cattle that become pregnant later in lactation spend a disproportionate amount of their lactation at lower levels of milk production, resulting in the loss of potential marginal milk. Reproductive inefficiency also costs the dairy by means of its impact on culling, since cows that fail to become pregnant during the breeding period are eventually culled once milk production has declined below economically viable levels. This forces the replacement of an otherwise healthy animal.

Calves represent the third potential source of value for improving reproductive performance. Bull calves are usually sold, resulting in an explicit source of income, but heifer calves are usually retained for replacement purposes. Heifer calves bring a large amount of value to a dairy, although the value is not usually in tangible dollars.

Dairy producers and veterinarians alike understand that reproductive inefficiency may be costly, but it is much easier to calculate the cost of hormonal interventions or additional labor that is often required to improve reproductive performance, as compared to estimating the potential future returns. For example, if a pre-synchronization program utilizing two doses of prostaglandin F2α given at 14-day intervals prior to breeding is implemented, one can estimate the expected cost by multiplying the number of cows that survive early lactation culling issues and enter the breeding population by the cost of the hormones and labor. Estimating the future returns, however, is much more problematic. Due to both the delay in receiving the benefit (dairies must wait at least 9-12 months to begin recouping the additional milk value) and the difficulty in associating the increase in milk production, increase in number of calves, and decrease in number of forced, non-pregnant culls, dairymen are often reluctant to invest large amounts of capital into timed artificial insemination (AI) programs, more inseminators, or other reproductive interventions.

Historically, dairy managers and consultants have used days open (DOPN) as the index for evaluation of reproductive performance and for estimating the losses of poor performance, with estimates of less than \$1 to over \$3 per day open.[1,3-6] Unfortunately, the use of average DOPN is a biased estimate and does not adequately estimate the current status of the majority of cows in the herd. Average DOPN only gives the interval from calving to conception for cows that have successfully conceived, and gives no information regarding non-pregnant cows. How do you assign a value to cows that fail to become pregnant, since only pregnant cows actually have a true DOPN? Also, the value of DOPN varies depending on current stage of lactation, price of milk, level of milk production, cost and availability of replacements and many other variables.[4,7,8] Utilizing a simple estimate such as \$2 per DOPN may grossly over- or underestimate the magnitude of the loss incurred by the herd.

Pregnancy rate (PR), defined as the proportion of eligible cows that become pregnant each 21-day cycle, is the preferred parameter for evaluating reproductive performance. It is more sensitive to detecting recent changes in reproductive performance and provides useful information, since non-pregnant animals also contribute to its calculation.[3] Based on database surveys as reported by Drs. Steve Stewart, Bruce Clark, Don Niles, and David Galligan (personal communications), PR in the US appears to average between 14-16%. Yet, a PR of 28-33% appears to be economically optimal, with most of the potential value captured once whole herd PR has reached 24-26%.[8]

There are limitations to the value of PR, however. First, PR does not inherently tell us about the economics of the reproductive program, only how fast pregnancies are occurring over time. Second, two herds could potentially have similar PR's, and yet have different numbers of pregnant cows as well as a different pattern for when the majority of cows became pregnant. For example, herd "X" that successfully utilizes a timed AI protocol for first insemination and then defaults back to a low, steady level of PR over time may have a PR of 18-19%, with many cows having very low DOPN. Herd "Y" may not take the same approach with the first insemination, but instead does a better job overall of the potential breeding periods. This herd could have a similar PR to herd "X", but the distribution of DOPN and pregnancies may be dramatically different. Obviously, the correct solution would be to combine the approach of herds "X" and "Y" such that herds start aggressively and continue with a high rate of pregnancy generation, resulting in a very high PR and few open cows at the end of the breeding period.

Many dairies have adopted various forms of timed AI programs in an attempt to increase their herd's PR, and in many cases, to simplify the breeding management by consolidating all of the inseminations into one day of the week. However, implementation of these TAI programs can be very expensive and many people wonder, "Is it really worth the effort?", "What is the cost?", "What should I expect in the way of returns?", and "Is it really that important to get all of my cows inseminated within the first 1-2 cycles?" The goal of the current paper is to use a spreadsheet-based model to demonstrate both the value of improving reproductive performance via the use of current timed AI programs, as well as the potentially substantial up-front costs associated with these programs, and to demonstrate the value of maintaining good compliance.

Model Building Information

A stochastic simulation model was built using Excel® spreadsheets and @RISK® simulation software. Earlier iterations of this model have previously been described.[2,7-9] Distributions describing conception risk (CR) and breeding submission risk (BSR) were fit from data obtained from approximately 95 herds representing approximately 150,000 cows (Niles, *et al* and other California dairies), and are used to mimic the normal variation seen between and within dairies across different 21-day breeding cycles. Daily milk and 305-day mature equivalent milk production estimates were also obtained from a variety of dairies and used to fit lactation persistency curves based on day in milk and level of herd milk production. Milk price estimates, market cow values, labor wage estimates, and other key inputs were derived either from published work or adapted from actual herd data. Culling risks over the entire lactation period were obtained from actual herd DairyComp 305 records and mathematically adjusted from 30-day to 21-day intervals to be consistent with the breeding cycles.

Simulated PR's are obtained by multiplying randomly generated samples from the CR distribution and BSR distribution for each 21-day period. Herd specific data that may influence on-farm profitability, including milk price, herd production level, replacement costs, herd replacement risks, market cow value, dry period length, wet calf value, stillbirth risk, pharmaceutical costs, labor costs and feed costs are entered. All values of change in PR are obtained by comparison of the modeled program with a baseline program. The baseline breeding program is a simple estrus detection-based reproductive program with CR and BSR distributions at each 21-day interval following a predetermined voluntary waiting period. Currently, the default average CR, BSR and resulting whole-herd PR is approximately 31, 51 and 16%, respectively, although each iteration of the model may yield different results, depending upon the sampled values used. The potential breeding period is twelve 21-day cycles for a total of 252 days of breeding. Simulated PR's from these traditional inseminations are obtained by multiplying randomly sampled values from the CR distribution and BSR distribution. The user can manipulate the baseline PR by applying a correction factor to the sampled CR, BSR or both, throughout the program, resulting in the desired cumulative starting PR that is used as the baseline for comparison.

This baseline program is then compared to one of three additional breeding management programs. The first is called an "improved baseline program" (IMP). This program is designed to mimic the changes that may be obtained as a consequence of improving CR, BSR or both over the course of the breeding period. No specific synchronization program is included in this program, although the user may input an additional expense to account for the improved performance. This model was designed to estimate the value that may be obtained by simply doing a better job with a traditional estrus detection-based program.

The second program that is used for comparison is a total timed AI program (TAI) and is based upon a Presync-Cosynch 72, with a d-32 re-synchronization.[10] This program includes an injection of prostaglandin F2α at approximately 36+/- 3 days-in-milk, followed in 14 days with a second injection. After an additional 14 days, cows receive an injection of gonadotropin-releasing hormone (GnRH), followed in seven days with another prostaglandin. At 72 hours, the final GnRH injection is given along with a timed insemination. No estrus detection is used. In the model, no ultrasound is used and instead, all cows are given an injection of GnRH 32 days post-breeding. In seven days, cows are examined via palpation per rectum and non-pregnant animals are given a prostaglandin injection and then proceed to complete the Cosynch portion of the TAI. Following this schedule, all non-pregnant cows are re-inseminated every 42 days until the breeding period is concluded.

The final program for comparison is a combination of estrus detection and TAI and is referred to as the modified Presynch-Cosynch program (MPS). Cows that follow this protocol receive two prostaglandin injections at 14-day intervals starting at 36+/- 3 days-in-milk. Cows that are observed in estrus after the second injection are inseminated per normal farm routine. Cows that are not observed within 14 days start the Co-Synch program as previously described. Afterwards, all breeding is performed based upon estrus detection. Thus, the second breeding cycle is composed of cows that are inseminated via estrus detection and cows that are inseminated by TAI, depending upon whether estrus was detected or not during the first breeding cycle.

In both the TAI and MPS programs, compliance to the protocol can dramatically affect both the cost and the benefit. Compliance in this case is defined as the proportion of cows starting a program that receive each of the injections and the insemination. The compliance distribution was fit from estimates compiled by the author, as well as estimates contributed by other veterinarians and from published work.[10] The resulting best fit was a beta general distribution with a mode of 92%, a mean of 88%, a median of 89%, a maximum of 99% and theoretical minimum of 60%. From a cost perspective, all cows present and eligible at the start of a program incur at least part of the hormonal costs. Cows that are deemed compliant are assumed to incur the entire cost of the injections, as per the schedule. Cows that are non-compliant or are culled during the 21-day period are assumed to incur half of the cost of the protocol.

The economic value of the change in PR is estimated by use of simple partial budgeting approaches. Each new program is compared to the baseline program by transferring the various outputs into its own partial budget (modifications of original work by Wolf) to compare predicted economic returns.[12] Sources of revenue include milk per cow per day over the year and annualized value of calves and market cows. Cows that are ultimately culled as non-pregnant, but are milked successfully until then, are removed from the dairy between the end of the breeding period and 750 days-in-milk. Expenses include cost of breeding management, replacement costs, marginal feed consumed, additional feed for any additional dry cows, and any additional housing, labor or medical expenses for the additional dry cows (if reproductive efficiency improves). Finally, the difference is adjusted for the time value of money, since returns occur in the future. All net returns are reported as dollars gained (or lost) per lactating cow slot on the dairy per year. The cow slot approach was taken because dairies calve more animals during a year than they actually milk, on average, at any given time. The cow slot approach allows the outputs to be adjusted back to the average herd size. The simulation software utilizes Monte Carlo sampling and runs 1000 iterations, displaying the results as probability distributions, with a mean and 90% confidence interval.

Estimation of Costs and Returns of Reproductive Change

To demonstrate the economic value of improving PR, the baseline program was set up to mimic a typical US herd milking an average of 1000 cows with a 16% PR and the following inputs: replacement cost - $1900, milk price - $13/ cwt, 305ME milk – 24,000 lb (10,909 kg), market cow value - $0.46/ lb with 7% mortality risk and 15% condemnation risk, lactating feed cost - $150/ ton, dry cow feed cost - $1.60/ day, labor cost - $13/ hour, prostaglandin cost - $2.75, and GnRH cost - $2.85. This baseline program is compared to IMP and MPS, each with an increase in PR of ~ two units (16 to 18% PR), and finally to the TAI program consisting of total TAI and no heat detection. Breeding fees are $18 per service and these include the cost of heat detection, AI service, supplies and semen. For TAI, the cost/ service is reduced to $13 to remove the estimated cost of daily heat detection.

In order to demonstrate the total up-front costs associated with each reproductive approach, individual marginal costs were calculated. Each of these costs are displayed below in Table 1, first on a herd basis of 1000 cows and then on a final per-cow basis. In the IMP program, the assumption was made that in order to gain in pregnancy rate without utilizing a TAI program, additional resources would be invested in terms of labor (an extra hour/ day for estrus detection) and the herd would utilize a palpation-based prostaglandin program. There are many options for utilizing prostaglandin, but since the pattern of pregnancy production in this program is similar to the baseline, no presynchronization was assumed. Instead, it was assumed that 0.5 doses would be used per cow slot per year to improve estrus detection based upon palpation per rectum.[11] The additional labor and prostaglandin costs were estimated at $1.38 and $4.75 per cow slot per year, respectively. Total insemination cost is $47,484, yielding a total reproductive management cost of $53,604 for the herd, or $54 per cow slot.

Table 1. Expected costs and returns associated with different approaches to reproductive management based on stochastic simulation modeling.

	Baseline program	Improved baseline (IMP)	Modified Presynch-Cosynch (MPS)	Presynch-Cosynch-Resynch (TAI)
Pregnancy rate (after 12 21-day cycles)	16.0%	18.0%	18.0%	16.4%
Prostaglandin program	-	$1,375	$5,985	$5,985
TAI hormone costs (GnRH, PGF, syringes, needles)	-	-	$4,136	$20,349
Extra management/ labor time (list, injections, or HD)	-	$4,745	$2,704	$8,112
Breeding costs (HD and AI fees, semen)	-	$47,485	$47,720	$29,484
Early GnRH for Resynch	-			$2,617
Total No. of inseminations (incl. culls)	2683	2638	2651	2268
Net No. of pregnancies (after culling)	757	784	775	778
Predicted DIM for Herd	199	189	191	194
Total (herd)	$48,290	$53,605	$60,545	$66,547
Cost/ cow slot	$48	$54	$61	$67
Cost/ pregnancy	$64	$68	$78	$86
Marginal costs for repro management (includes AI expenses, semen, labor and hormones, but no heat detection)				
Total (herd)	$13,411	$19,310	$26,081	$66,547
Marginal cost/ cow slot	$13	$19	$26	$67
Marginal cost / pregnancy	$18	$25	$34	$86
Predicted net returns (per cow slot per year)	Referent	$36	$13	$19

In the MPS protocol, all cows that reach the voluntary waiting period are assumed to have received two doses of prostaglandin F2α given at 14-day intervals. However, there are a substantial number of cows that leave the typical dairy during the first 30-60 DIM. In the model, 1180 cows calved and 1075 reach 50 DIM. The first injection is given at 33 DIM and by this time, ~ 75% of the cows that will be culled prior to the end of the voluntary waiting period have already left. For the remaining cows that have survived until this point, but will be culled prior to entering the breeding population, I assumed that on average, each cow received one dose (26 cows x $2.75 = $72). All other cows are assumed to have received both doses (1075 x ($2.75 + $2.75)) = $5913). Breeding occurs for cows observed in heat, with the remaining cows being enrolled into the Ovsynch program. I estimated 50% heat detection and an additional 1.8% culled during the first cycle results in ~ 518 animals eligible for enrolment into the Ovsynch program. With 89% compliance, 461 cows receive the entire cost of the protocol ($3895) and 57 cows incur half of the cost ($241), resulting in a total Ovsynch hormone cost of $4136 for the herd. From a management perspective, I assumed that administration time to create and print the list for the workers would consume about two hours/ week for the herdsman/ manager. The additional labor cost is $2704, resulting in a total cost for the synchronization portion of $12,825 for the herd or $12.83/ cow slot for the year. After the second cycle, all remaining breeding is identical in approach to the baseline program and no additional costs are assumed beyond the normal cost per service of $18. With 2651 services, the total insemination cost is $47,720, bringing the total reproductive management cost for this approach to $60,546 for the herd or $61 per cow slot per year.

For the TAI protocol, the approach to the pre-synchronization is identical to the MPS protocol, resulting in a total pre-synchronization cost of $5985. Each breeding is based on TAI and as a consequence, the total cost is a function of number of cycles, interval between breedings, compliance to the protocol, and how many cows are culled during the breeding period. Using the same expected compliance estimate of 89%, and assuming that all inseminated cows receive an injection of GnRH on day 32 post-breeding, but prior to pregnancy determination, and the breeding period lasts for 252 days, there are six possible services and a total of 2548 potential breedings. With the TAI protocol, there is no heat detection and the service cost, including semen and AI personnel, is estimated at $13/ insemination. After accounting for culling and compliance, 2268 cows are actually inseminated resulting in service fees of $29,484 and hormone cost of $19,165. List administration time was estimated to take two hours per week for the herdsman or manager and eight hours per week, split between two workers, to find cows and administer the injections. Total labor cost is $8112. Next, I assumed that the cows lost to culling or poor compliance (280) incurred half of the normal TAI hormonal cost ($1184). Finally, to account for the early GnRH re-synchronization cost, every cow inseminated that was not culled prior to day 32 was assumed to have received an additional injection of GnRH to initiate the re-synchronization, but cows that are later found open have already previously been charged for the full cost of re-synchronization. Therefore, the only cows that count in this section for the cost of the early GnRH are pregnant cows that were not culled since the previous insemination, or non-pregnant cows that fail to survive to pregnancy evaluation (918 x $2.85 = $2617). The final result is a total breeding management cost of $66,548, or $67 per cow slot.

The results shown in Table 1 illustrate the variation in up-front costs for the different approaches to reproductive management. Of the three options for improving reproductive performance, the improved baseline program yields the greatest total return of $36 per cow slot per year, the lowest cost per cow or per pregnancy, and lowest marginal cost for reproductive management. Due to the lower up-front costs, many dairy producers choose to take this approach thinking that if they can only get their personnel to do a better job with estrus detection and conception risk, they can improve their bottom line most economically. I agree that this should be the first approach taken when trying to improve reproductive performance, but many dairies fail to improve significantly using this approach and instead, turn to an alternative approach that usually incorporates some form of TAI such as option 3 or 4 above. Of the two alternatives utilizing TAI, the modified Presynch-Cosynch approach is less expensive, but yields a lower return ($13 vs $19) per cow slot per year. These economic returns must be interpreted with some caution. Returns associated with changes in reproductive performance depend upon a wide variety of factors, including level of milk production in the herd, the price of milk, cash cost of replacing cows, and the herd's starting level of reproductive performance. In the above examples, milk price was set at $13.00/ cwt, herd production was 24,000 lb (10,909 kg) 305ME, average cash cost for replacements (purchase minus beef value, including dead and condemned) was ~ $1400, and the baseline PR for comparison was 16%. Had the baseline been lower, the same 2-point improvement in PR would have been more valuable across all three programs, and conversely, if the starting baseline was already higher than 16%, the returns would have been lower.

Some dairy producers have made the change from traditional estrus detection programs in favor of total TAI programs such as the Presynch-Cosynch 72 with Resynch. This program has become more popular because it allows dairies to concentrate reproductive management labor into a couple of days per week, depending upon the specific approach taken. However, many producers are still reluctant due to the cost of the program and because the reported PR's are not as high as they had hoped. Figure 1 shows the expected results for the

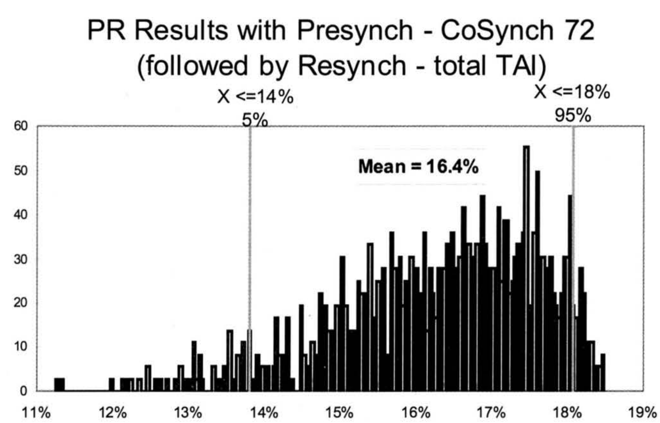

Figure 1. Distribution of modeled PR results for Presynch-Cosynch 72 Resynch as compared to a baseline of 16% PR.

previously described TAI program. The mean PR is 16.4%, with 90% of the outcomes predicted to lie between 14 and 18%, depending upon the level of compliance and conception risk per insemination. However, one must remember that part of the issue with the lower than expected PR's is that there are no cows inseminated in the first 21 days. Mathematically, having no cows pregnant in the first 21 days depresses the calculated PR, but as shown previously, in Table 1, may still produce more pregnancies than traditional programs with similar PR's due to the ability to more consistently get cows pregnant during the later breeding cycles.

Figure 2 shows the predicted economic returns for TAI. Consistent with Table 1, the mean return is $19 per cow slot per year, considering all of the previously calculated management and breeding costs. In this set of 1000 iterations of the model, the baseline PR was held steady at 16% as were all of the other variables with distributions, except for the compliance and conception risk estimates for each insemination. There are a couple of different ways of interpreting this graph. First, one could state that the average expected return is about $19 and that 90% of the time, the predicted economic return was between -$25 and $42 per cow slot per year. The second way of interpreting these results is that 78% of the time, the model predicts that TAI would provide a higher economic return than the traditional baseline program of 16% PR.

One large source of variation impacting both the predicted PR and the profitability of TAI is the level of compliance. As previously defined, compliance refers to the percentage of cows that complete the TAI program once they have received the first GnRH injection. The variable and potentially low level of compliance is the primary reason for the 22% probability of experiencing an economic loss in Figure 2 above. If compliance is stable at 90% over all potential inseminations, the results are dramatically different, as shown in Figure 3. Reasons for poor compliance include not finding all of the cows on the list due to movement of cows to other pens, poor lockups, cows being culled and misidentification of cows.

Regardless of the reason, poor compliance is very costly. Figures 4 and 5 below further illustrate the impact of failing to follow through with the reproductive protocols for both total TAI and for MPS. In the first program, all inseminations occur due to protocol, with no estrus detection occurring. Therefore, mistakes are extremely costly. In this graph, the average results of varying levels of compliance across all potential inseminations are displayed. Based on these estimates, if herds are consistently below ~ 85%, the program is predicted

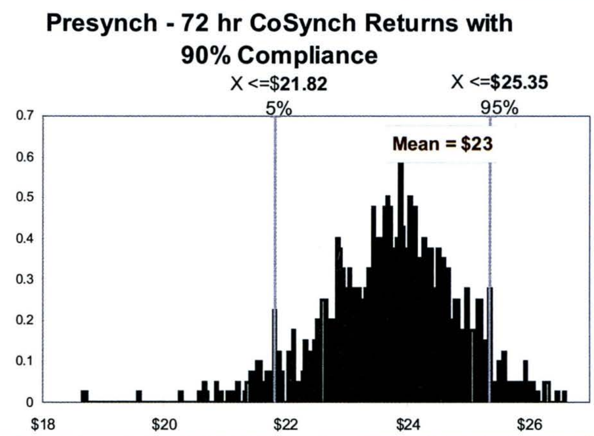

Figure 3. Predicted returns from TAI if compliance is consistently 90% across all potential cycles.

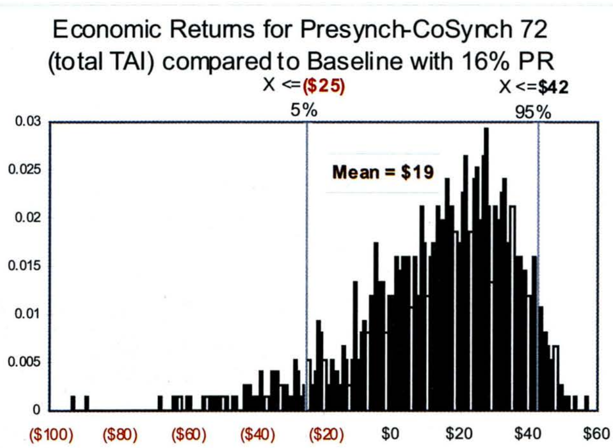

Figure 2. Distribution of modeled economic returns for Presynch-Cosynch 72 with Resynch as compared to a baseline of 16% PR.

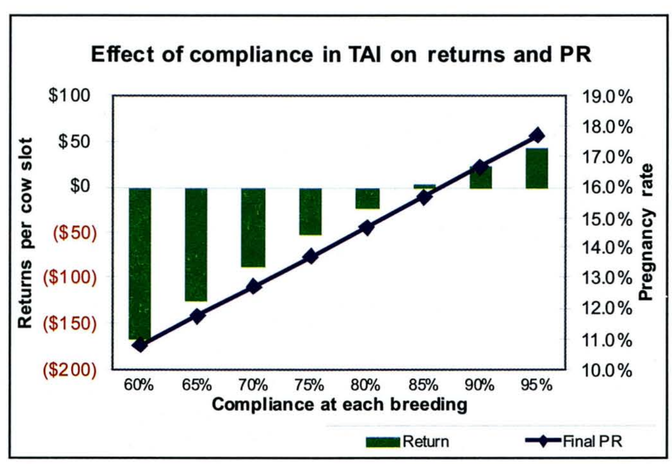

Figure 4. Predicted changes in economic returns and PR for Presynch-Cosynch 72 with changes in level of compliance for all inseminations.

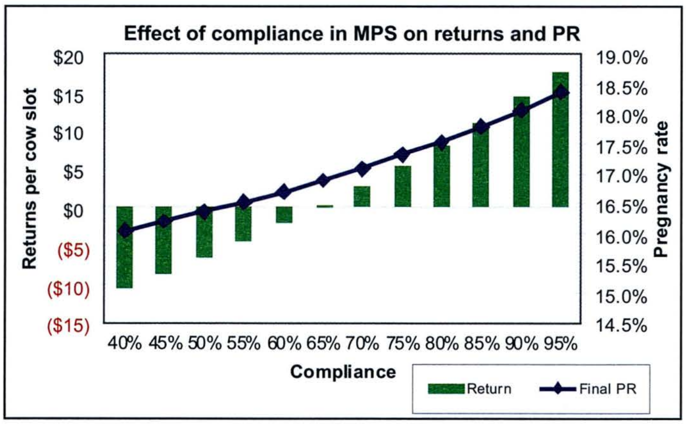

Figure 5. Predicted changes in economic returns and PR for Modified Presynch-Cosynch with changes in level of compliance to TAI in second cycle.

to lose money as compared to a baseline estrus detection program achieving steady state 16% PR.

Figure 5 illustrates the impact of poor compliance on the MPS or a "back-door" Cosynch program. In this management scheme, estrus detection occurs continuously and a certain percent of cows receive a timed insemination during the second cycle. This protocol has been widely adopted in an attempt to try and deliver semen to all cows within the first two 21-day cycles of the breeding period. As compliance drops from a high of 95%, the predicted PR and profitability declines, but not as severely as in the TAI protocol, since estrus detection is still occurring. I assumed that cows missed due to poor compliance would still be eligible for insemination if detected in estrus, based on the cycle-specific estrus detection risk. Some advisors believe that herds may experience a drop in estrus detection efficiency as a consequence of "over-reliance" on TAI. Other concerns are often expressed regarding the potential effect of poor compliance on overall CR. These scenarios were not investigated in this paper.

Conclusions

The potential economic return associated with improving reproductive performance in dairy herds depends upon a wide variety of factors, including current level of reproductive performance, price of milk, value of calves produced, cash cost of replacement heifers, and many others. The lower the current PR, the greater the potential reward from improving reproductive efficiency. A variety of synchronization programs have been developed that may help improve the overall PR of the herd, but the profitability of each program varies.

With the current spreadsheet model, both the MPS and TAI programs improved the profitability of the modeled herd by increasing the number of pregnant cows and decreasing the predicted DIM for the herd. Compared with the baseline herd, the MPS netted 18 more pregnancies over a 252-day breeding window and yielded a predicted economic return of $13 per cow slot per year, after considering the costs of the breeding management as entered in the model and the effects of culling throughout the lactation. Similarly, the TAI program netted 21 more pregnancies and an additional $19 per cow slot per year for the dairy. However, both programs have significant up-front costs associated with their use and the returns will not begin to appear for nine-to-12 months. The MPS program was less expensive than the TAI program in terms of marginal reproductive costs per pregnancy ($34 vs $48, respectively), but the additional profit predicted from the TAI program more than covered the increased marginal cost.

The adoption of either of these programs carries significant potential risk if not properly implemented and managed. Poor compliance to either program dramatically decreases both the resulting PR and the predicted economic returns. Due to the presence of continuous estrus detection, the MPS approach was less sensitive to compliance issues as compared to the TAI program. Dairies that implement programs such as these should work diligently to ensure that compliance levels consistently exceed 90% in order to maximize the profitability of either approach.

The baseline herd that served as a comparison for the model was designed to have a 16% PR, consistent with a typical herd in the US. Herds that are already above this level of reproductive performance should carefully consider their current level of efficiency and the risks/ rewards of the potential new approach, as potential returns are likely much smaller given the higher starting PR. Results, as well as economic returns, will vary from herd to herd depending on a wide variety of factors. The current paper presented the results of a modeled approach to reproductive management and is not a guarantee of future performance or profitability.

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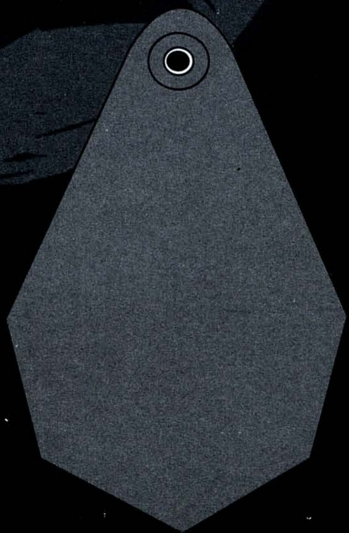

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New Class of Chemistry – AVENGER™ is not a pyrethroid or an organophosphate. AVENGER™ utilizes the active ingredient endosulfan – a brand new chemistry class.

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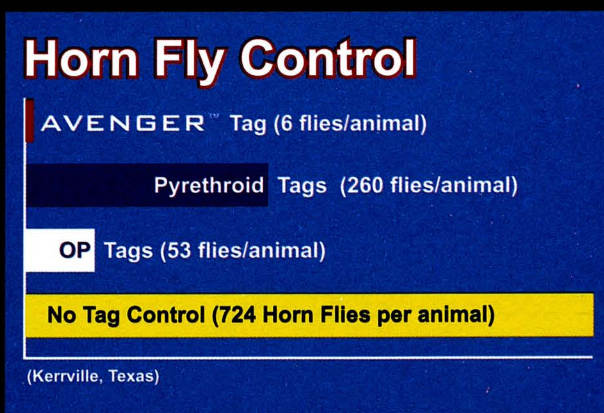
Approved on Lactating Dairy Cows – AVENGER™ is approved for use in all lactating dairy cows and does not affect milk production safety.

Safe, Effective and Cost-Efficient – Effective against horn flies and other pests for up to five months and aids in the control of face flies, the mechanical vector of *Moraxella bovis* bacteria.

No Offensive Odor – Unlike many insecticide cattle ear tags, AVENGER™ has no offensive odor or tacky coating.



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