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Case Study–Effect of Implementation of a Systematic Reproduction Management Program in Dairy Herds

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Abstract

The objective of this field study was to measure the effect of implementing a simple systematic reproduction management program in dairy herds with reproductive performance near or below typical in the industry. Thirty-nine herds across Canada that had annual herd 21-day pregnancy rates (PR) between 8 and 15%, and did not have a systematic reproduction program, were enrolled in a program that consisted of: enrollment of cows that were not inseminated by 70 days-in-milk into a timed insemination program (Ovsynch); enrollment of cows diagnosed not pregnant on Ovsynch; and a change to biweekly veterinary visits for reproductive management. Annual herd PR was compared one year after implementation of the program. On average, the systematic management program was associated with a mean increase in PR of 3.6 percentage points (95% confidence interval, 2.5 to 4.7; P<0.0001), accounting for initial insemination and conception rates, herd size and method of pregnancy diagnosis. Assuming a milk price of $23/cwt to reflect Canadian milk price net of purchase of quota, economic analyses indicated that herds that increased PR by at least two points were estimated to have an annual net profit improvement between $20 and $250 CDN per cow, depending on the initial PR and the magnitude of the increase in PR. Overall, 72 to 77% of herds that implemented the program were estimated to have a net economic benefit.

Keywords: bovine, dairy, reproduction, Ovsynch, economics

Résumé

L'objectif de cette étude sur le terrain était de déterminer l'effet de l'adhésion à un simple programme systématique de régie de la reproduction dans des troupeaux laitiers performants près de la normale ou sous la normale. Un total de 39 troupeaux à travers le Canada ayant un taux de gestation calculé sur 21 jours entre 8 et 15% annuellement et qui n'adhéraient pas à un programme systématique de reproduction, ont été enrôlés dans un programme qui comprenait les éléments suivants: enrôlement des vaches qui n'étaient pas inséminées au 70^{e} jour en lait dans un programme d'insémination sur rendez-vous (Ovsynch); enrôlement des vaches diagnostiquées non-gestantes avec le programme Ovsynch; et un changement de l'horaire des visites vétérinaires aux deux semaines pour la régie de reproduction. Le taux de gestation annuel des troupeaux a été comparé un an après l'adhésion au programme. En moyenne, le programme de régie systématique était associé avec un accroissement du taux de gestation de 3.6 points en pourcentage (intervalle de confiance à 95%, 2.5 à 4.7, $p < 0.0001$), tenant en ligne de compte les taux initiaux d'insémination et de conception, la taille du troupeau et la méthode de diagnostic de la gestation. En assumant un prix du lait de 23$/cwt pour refléter le prix canadien du lait excluant le prix d'achat du quota, l'analyse économique montrait que les troupeaux dont le taux de gestation avait augmenté par au moins 2 points en pourcentage avait un accroissement du profit annuel net estimé entre 20$ et 250$ par vache dépendant du taux de gestation initial et de la magnitude de l'accroissement du taux de gestation. Dans son ensemble, on estime qu'entre 72 et 77% des troupeaux auraient un avantage économique net en adhérant au programme.

Introduction

Reproductive performance is an ongoing challenge on the most dairy farms, and is consistently among the top concerns of producers and veterinarians. There is considerable economic opportunity cost incurred by longer-than-optimal intervals to pregnancy, and by failure to achieve pregnancy in otherwise profitable cows.[6] Many factors influence reproductive performance, but in many herds the efficiency of inseminating open cows is one of the first and greatest limiting factors.[4] However, with practical timed insemination protocols that produce acceptable conception risk (i.e. Ovsynch) insemination rate can be entirely controlled by management. Ovsynch is a program for synchronization of ovulation in cows culminating in timed artificial insemination (AI) without detection of estrus. Ovsynch consists of an injection of gonadotropin-releasing hormone (GnRH) followed seven days later by prostaglandin $F_{2\alpha}$ (PGF), then GnRH 48 hours later with timed AI (TAI) within 24 hours of the final injection.[8]

Among approximately 4,000 herds in Ontario and western Canada with valid reproduction data calculated with DairyComp 305[a] software in 2004, the average performance was as follows:[7] pregnancy rate (PR; the probability that open cows, eligible to be bred, become pregnant in a 21-day period) = 13%; insemination rate (IR; the probability that open cows, eligible to be bred, are inseminated in a 21-day period) = 35%; and conception risk (CR; the probability that an inseminated cow is diagnosed pregnant to that insemination) = 38%.

There are variations of Ovsynch available, e.g., Presynch (two injections of PGF preceding Ovsynch to optimize the stage of the estrus cycle for initiation of Ovsynch) or Resynch (re-enrollment of non-pregnant cows into Ovsynch at a specific interval after a previous AI by Ovsynch), which seek to optimize the probability of pregnancy at the TAI.[8] The optimum protocols for these programs are the object of much ongoing investigation. The criteria for selection of cows or herds in which to implement one program or another for maximum economic benefit are not clear, and merit large-scale field research.

Several field studies have shown that systematic, rather than selective, reproduction management programs produce improved herd reproductive performance.[1,5,12] A first, large step toward improved PR in many herds would be to move to a systematic program that reduces the absolute value and the variability of the intervals from calving to first AI, and from diagnosis of non-pregnancy to re-insemination.

Many herds have adopted timed insemination programs as a tool to manage some or all breeding in the herd. A survey of Canadian dairy producers in 2003 indicated that although 68% had used the Ovsynch program on some cows, only 13% used a synchronization program on more than 50% of milking cows for first service.[13] Miller *et al*[9] estimated that 20% of herds in the US in 2005, representing 35% of dairy cows, had adopted a synchronization program, resulting in shorter times to pregnancy than in other herds, on average.

Many studies seek incremental increases in CR from TAI programs by adjusting the timing of injections or optimizing the stage of the estrus cycle for interventions.[2] While these are useful pursuits, there remain many herds, both small and large, that have PR at or below industry averages–and well below optimal levels–which have not implemented a systematic reproduction management program (SRMP) of any kind. Such herds commonly manage reproduction on an individual cow basis, frequently with reliance on rectal palpation to guide interventions.[13]

This study was directed at producers not using SRMP because of concerns over cost or due to lack of understanding of the benefits. Specifically, the intent was to evaluate the performance and economic effects of moving herds from approximately the third quartile of PR in the dairy industry into the upper second quartile. The hypothesis was that implementation of a simple systematic program for insemination, supported by the herd veterinarian, would profitably improve herd PR by increasing IR in herds with average or below-average PR and without a systematic program. The objective of the study was to evaluate the effect of implementing a SRMP in dairy herds.

Methods

The unit of interest was the herd, and the herd 21-day PR was the main outcome measured. The study compared herd PR for the 12 months preceding implementation of the SRMP (March 2005 through February 2006) to the PR for the 12 months after the program was put into place (March-April 2006 through March 2007). This helped account for month-to-month variability and seasonal effects on PR.

The study herds were a convenience sample of 43 commercial dairy herds with a total of approximately 3,300 cows, with representation from each of the major dairy regions in Canada. Herd inclusion criteria were that 1) the herd was enrolled on Dairy Herd Improvement Association (DHIA) milk recording; 2) the herd average PR for 12 months before the study was between 8 and 15%; 3) the herd was not using a SRMP (selective or occasional use of prostaglandin injections or Ovsynch before the study was allowed); 4) used AI breeding exclusively; and 5) all inseminations and pregnancy diagnoses were accurately recorded. Herds were identified and recruited by their veterinarians. All veterinarians were in predominantly or exclusively dairy practice, and continued as the herd veterinarian throughout the study.

Herd PR data were obtained for each herd in March 2006. The baseline (prior to implementation of the study program) PR was calculated for the 12-month period before the start of the study. All herds then implemented the study protocol, which had three components: 1) cows that had reached 70 days-in-milk (DIM) and had not received AI were enrolled on Ovsynch with the next biweekly group to start on Ovsynch; 2) when a cow was diagnosed not pregnant, that cow was then enrolled on Ovsynch with the next biweekly group; and finally, 3) the herd instituted a biweekly visit by the herd veterinarian for pregnancy diagnosis of the milking cows. The Ovsynch protocol used in this study was

GnRH (100 µg) – 7 d – PGF – 48 h – GnRH – 12-16 h – TAI. The specific gonadorelin product used was the discretion of the herd veterinarian. The PGF was 25 mg dinoprost.[b] All GnRH and PGF needed to fulfill the study protocol were provided free of charge to the herd throughout the study. Because all herds started a new group of cows on Ovsynch biweekly, the first AI for cows bred by Ovsynch would occur on average at 87 DIM, and first AI would occur at the latest by 94 DIM. Up to 5% exceptions were allowed, i.e., cows that could be selectively managed outside the study protocol. For each AI, producers were asked to enter a code to indicate whether the insemination was based on detected estrus or by Ovsynch. Pregnancy was diagnosed by the herd veterinarian. The method (palpation or ultrasound) and minimum interval after AI at pregnancy diagnosis were recorded for each herd.

Herd owners or managers completed a brief written questionnaire at the start of the study that collected information about the type of housing (tie stall or free stall), methods of heat detection employed in the herd, milking frequency, floor surface in the cattle housing area, and their reasons for taking part in the study. At the end of the study, a second questionnaire collected data on the method of keeping track of tasks for the reproduction management program. At the end of the study, but before any formal feedback of results, participating producers were also surveyed by written questionnaire about whether they would continue with a similar reproduction management program after the study, at which time they would have to pay for GnRH and PGF.

Pregnancy rate was calculated for most herds using Dairy Comp 305 software (Bredsum\E command, using a voluntary waiting period (VWP) of 50 DIM). The calculation is the probability of pregnancy per 21 days in cows past the VWP, not already pregnant or recorded as not to be bred, and present in the herd for the full 21-day period. For herds in Quebec, PR was calculated with DSA[c] software. The calculation was similarly the probability of pregnancy per 21-day period with a 50-day VWP, based on the 42 most recent eligible time periods. For all herds, PR was calculated for a full 12-month period before and after implementation of the reproduction management protocol.

As a herd-level outcome, PR is a continuous variable with an expected normal distribution. The sample size for the study was calculated to detect a change in PR from 13% to 17% with a 6% standard deviation, 95% confidence and 80% power, which required at least 35 herds.[3]

Data were extracted from each herd and summarized in Microsoft Excel.[d] Statistical analyses were performed with SAS version 9.1.3.[e] The effect of implementing the protocol on herd PR was measured with a mixed linear regression model (Proc Mixed in SAS), including herd as a random effect, and the following covariates: mean number of milking cows in the herd; region (Atlantic/Quebec, Ontario, western Canada); type of housing (freestall or tiestall); method of recording-keeping; main method of heat detection; the method of pregnancy diagnosis by the herd veterinarian (ultrasound or palpation); initial IR; initial CR; proportion of AI during the study that were done by Ovsynch; and the proportion of AI during the study that occurred before 94 DIM (an estimate of compliance with the protocol). The model was built by manual backward stepwise elimination.

For economic analysis of the results of the study, the following costs were assumed (all in Canadian [CDN] dollars; at the time of the study, \$1 CDN ≈ \$0.85 US): 1) PGF = \$5/dose; 2) GnRH = \$3/dose; 3) one additional veterinary call fee per month to move to biweekly herd visits = \$30/month for all herds; and 4) net increase in veterinary time per month at \$120/hour–for herds with less than 100 milking cows, 30 minutes per month; for herds with more than 100 milking cows, 60 minutes per month. Therefore, the fixed annual increased cost of going from monthly to biweekly visits for reproduction was \$1080 for herds with less than 100 cows, and \$1800 for herds with more than 100 cows.

Two methods were used to estimate the economic benefit of the change in PR net of program costs. Data were not collected on the cost of semen and changes in the amount of labor during the study, so these inputs were not considered in either economic analysis. For the 10 herds that did not record complete data on breeding codes (Ovsynch or detected estrus), it was assumed that 80% of AIs were done by Ovsynch, i.e., they were assigned the maximum recorded value, and the highest cost was assumed.

The first method was the stochastic model of Overton,[10,11] with the following inputs: \$23/cwt milk price (intended to reflect Canadian milk price, net of \$20/hectolitre principal and interest cost for purchase of additional quota for marginal milk produced per cow in the herd if PR increased), 23,420 lb (10,650 kg) 305 mature equivalent (ME) herd production, 36% annual culling, 50 day VWP, \$1236 cost of a replacement heifer, \$356 value for a culled cow, 8% interest, \$13/hour labor, \$125 value of a bull calf, \$200 value of a heifer calf at birth and 8% stillbirth. These values approximated market conditions in Canada at the mid-point of the study. Based on these inputs, the economic benefit of changing herd PR from 10% to 26% was estimated to be \$66/milking cow/year/point of PR between 10 and 12% PR; \$54/cow/year/point of PR between 12 and 14%; \$40/cow/year/point of PR between 14 and 16%; \$29/ cow/year/point of PR between 16 and 18%; and \$20/cow/year/point of PR between 18 and 20%. A logarithmic function that described the model output (R^2 = 0.96) was used to calculate the marginal annual economic value per cow of the PR at the end of the study relative to PR at the start for each herd.

The second method of economic evaluation was that of Fetrow (John Fetrow, personal communication). This spreadsheet calculates the increased number of pregnancies associated with a change in herd PR, uses a fixed, user-inputted value of pregnancies and accounts for the user-inputted cost of increasing PR. The number of cows eligible for breeding per 21-day period was the annual average number of cows eligible for breeding per 21-day period at the start of the study. The value of a pregnancy was fixed at $460, based on calculations from a sample of 50 herds in Canada, using the Pregnancy Value model with default inputs from DairyComp 305, as described elsewhere.[6]

Results

Forty-three herds started on the study; one herd had a barn fire, one abandoned the study after six months and two herds did not maintain adequate records to accurately measure PR. Therefore, 39 herds, served by 31 veterinarians, were included in the final analyses; two in Atlantic Canada, eight in Quebec, 24 in Ontario and five in western Canada. The mean (± SD) number of milking cows was 78 ± 42 (range from 30 to 210; median = 65) and mean (± SD) herd average 305 ME milk production was 23,736 ± 2512 lb (10,789 ± 1142 kg). In 32 herds lactating cows were housed in tie stalls and in seven herds they were in free stalls. Thirty-eight herds milked twice daily, and one milked three times daily.

Descriptive statistics for herd reproductive performance at the start and end of the study are in Table 1. The effects associated with herd PR at the end of the study are described in Table 2. Implementation of the reproduction management program was associated with a 3.6 percentage point increase in herd PR (95% confidence interval = 2.5 to 4.7 points; $P < 0.0001$), accounting for the effects of initial IR and CR, herd size and use of ultrasound for pregnancy diagnosis. Herd size, housing type, region, the proportion of AI during the study that were done by Ovsynch (mean ± SD = 54 ± 16%; range from 23% to 80%; n = 29 – there were 10 herds with otherwise complete data that did not record the code [Ovsynch or detected estrus] for all AI) and the proportion of AI during the study that occurred before 94 DIM (mean ± SD = 88 ± 9%, range from 56 to 100%) were not associated with PR at the end of the study. Interestingly, whether considered alone, or accounting for the other variables in Table 2, the effect of the reproduction program was identical, a 3.6 point increase in herd PR. The changes in PR that occurred over the study are described in Figures 1 and 2. Thirty-two of the 39 herds (82%) had increased PR at the end of the study compared to before the study; 25 herds (64%) had

Table 1. Descriptive statistics of annual reproductive performance in 39 dairy herds before, and one year after, implementation of a systematic reproductive management program.

	Before			After		
	mean	SD	Min. – max.	mean	SD	Min. – max.
Pregnancy rate	11.6	1.9	8 to 15	15.2	3.6	7 to 22
Insemination rate	37.0	6.8	24 to 48	45.0	6.0	29 to 61
Conception risk	33.3	7.0	14 to 50	34.3	8.7	18 to 52
Median time from calving to first insemination	82.7	11.8	63 to 117	80.6	7.2	67 to 100

Table 2. Mixed linear regression model of change in herd annual 21-day pregnancy rate (PR) one year after implementation of a systematic reproduction management program in 39 dairy herds in Canada with initial PR between 8 and 15%.

Variable	Effect on PR	Standard error	P
Regression Model Intercept	2.64	3.61	-
Reproduction management program	3.60	0.57	< 0.0001
Initial Insemination Rate (per 1 point increase)	0.16	0.06	0.009
Initial Conception Risk (per 1 point increase)	0.23	0.06	0.0002
Pregnancy diagnosis by ultrasound (relative to palpation)	1.08	0.60	0.08
Herd size (per increase of 10 milking cows)	-0.18	0.01	0.02

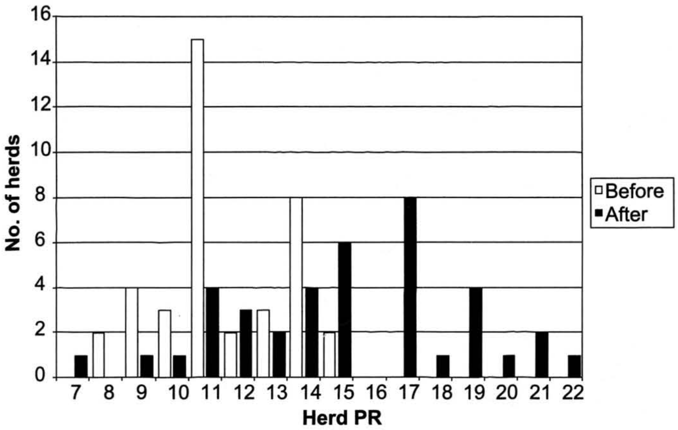

Figure 1. Distribution of annual 21-day pregnancy rate in 39 dairy herds before and after implementation of a systematic reproduction management program.

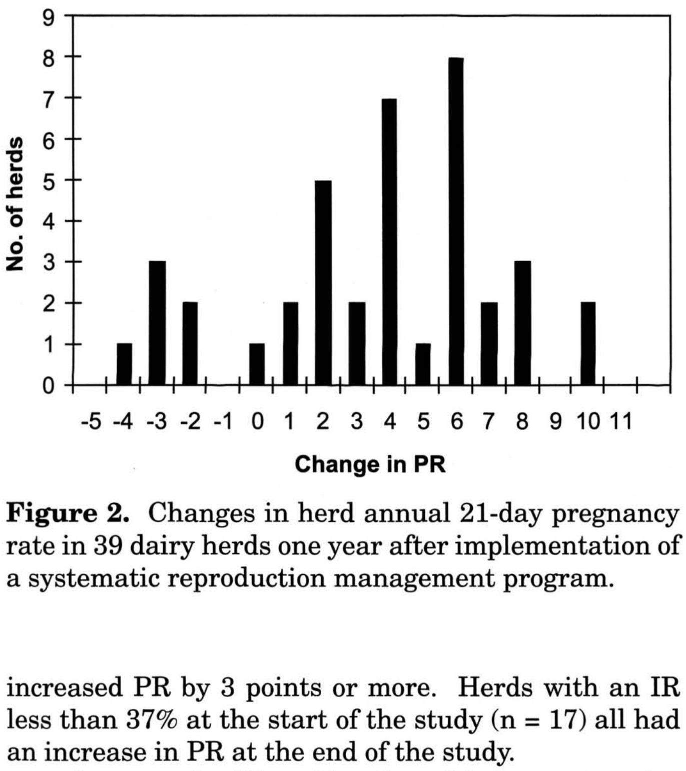

Figure 2. Changes in herd annual 21-day pregnancy rate in 39 dairy herds one year after implementation of a systematic reproduction management program.

increased PR by 3 points or more. Herds with an IR less than 37% at the start of the study (n = 17) all had an increase in PR at the end of the study.

An example of the estimation of the economic value of implementation of the SRMP by the second method described above is provided in Table 3. Results of the two methods of economic analysis are summarized in Table 4. As expected, herds with decreased PR would have lost money on what they spent to implement the reproduction management program. While there were differences in the estimated economic returns due to differences in the two methods, both consistently indicated that, given the assumptions and the conditions observed, herds that increased PR by 3 points or more had a net profit that varied from $20 to over $250 CDN per cow for the year. Herds with a gain of only 1 point of PR were estimated not to benefit economically, while the estimated returns for those with a gain of 2 points of PR were equivocal. Overall, 72% (method 2) to 77% (method 1) of herds gained economically from implementation of the program.

Information to explain the differences between herds that experienced a profitable increase in PR and those that did not was limited. However, among 32 herds with increased PR over the course of the study, mean IR at the start of the study was 36%, and increased to a mean of 45% at the end of the study. In contrast among the seven herds that had no change or lower PR, mean IR at the start and end of the study was unchanged at 45%. Conception risk did not change significantly in either group, but was 34% at the start and 37% at the end of the study among the herds with increased PR, and 32% and 25%, respectively, in the herds with no improvement in PR.

At the end of the study but before economic analysis was provided to them, 38 of the 39 participating producers (97%) responded that they would continue with a similar reproduction management program into the future.

Discussion

This study measured the impact of a change in reproduction performance in the first year following a change in reproduction management in small dairies in Canada. The aim was to implement a systematic but simple program. The intent was not to eliminate estrus detection, but to place upper limits on the time to first AI, and from diagnosis of non-pregnancy to re-insemination. In addition, we did not attempt to employ the most advanced versions of TAI programs (e.g. Presynch or Resynch), but rather to implement a straightforward system that was expected to improve IR over the previous performance. Herds selected for the study had PR that were in the third or second quartile of the dairy industry and did not use reproductive management programs in a systematic way before the study.

While there are many studies on development or refinement of synchronized breeding protocols, the present study is one of few to measure the longer-term effects of implementation of a reproduction management program and to estimate the economic returns at the herd level under field conditions. The use of a large number of herds makes generalization of the results to other similar herds more valid. We emphasize that this was a herd-level study, not an individual cow-level study. It would be ideal from the standpoint of experimental design to randomly allocate half the cows within each herd to be managed by the existing or the new reproductive management program. However, such a study is not practically feasible in a large number of commercial herds. A weakness of this study is that it was not possible to collect detailed information about all of the numerous variables that may have influenced the direction and magnitude of change in herd PR during the study period. For example, details about feed quality, heat stress and the incidence of metabolic or infectious disease were not available. However, various confounding effects were likely distributed among all of the herds. It is interesting to note that in herds that had increased PR, the change was driven largely by an increased IR, which was the premise of the study. Conversely, herds that had no improvement in PR generally had higher IR at the start, with no change over the study; these herds also had apparently lower CR over the course of the study. Implementation of the SRMP was not expected to change CR. While it is not clear why herds with no improvement or lower PR had apparently reduced CR, this observation is consistent with the hypothesis that the SRMP did not cause the reduction in PR.

It was expected that the two methods of economic analysis would yield different estimates of the economic benefit of increased PR. The spreadsheet by Fetrow assumes a fixed marginal value of pregnancy, while Overton's model reflects the diminishing returns as PR increases into the high 'teens and twenties'. Both models are sensitive to herd size. Fetrow's spreadsheet may underestimate the value of additional future milk produced per stall as a result of improved PR, particularly for herds starting with lower PR, but it has the advantage of simplicity and may be considered to be a conservative estimate of the economic benefit of implementation of a SRMP. It should be noted that the value of economic return using Overton's method is higher than reported elsewhere[10] because in the present analysis the assumed milk price was higher ($23/cwt milk price to reflect Canadian milk price net of purchase of quota).

As expected, the main driver of the economic gain was the magnitude of change in PR. The PR model (Table 2) indicated a small but significant inverse relationship between herd size and final PR. Although the basis of such a notion is unclear, a perception exists among the owners of some herds that theirs is too small for a SRMP to be relevant or profitable.[13] The results of the present study refute this misconception.

It was interesting (Table 2) that herds in which pregnancy diagnosis was performed by ultrasound tended to have PR approximately 1 point higher than herds in which pregnancy was diagnosed by palpation. This finding supports the value of finding non-pregnant cows earlier if prompt action is taken to re-inseminate them, which in this case meant enrolling open cows in the next Ovsynch group. This finding should not be generalized to draw inferences about the merit of ultrasound versus palpation for pregnancy diagnosis because this was not an objective of the present study, and may have been confounded by other factors.

Table 3. Sample calculation of estimation of the economic benefit of implementing a systematic reproduction management program, using method 2 (see text). The herd in this example had 70 milking cows (Herd 20 from Table 4).

Variable	Source	Value	
Initial pregnancy rate	Input from herd data	13	A
PR after implementation of the program	Input from herd data	19	B
Change in PR	B - A	6	C
Cows eligible for insemination (exposed to the program) per 21-day period	Input from herd data	26	D
Cost of Ovsynch per cow	Assumption – see text for details	$11	E
Proportion of inseminations done by Ovsynch	Input from herd data	0.4	F
Additional cost per 21 days	D*E*F	$114	G
Value of making a typical cow pregnant	Typical value from calculation – see text for details	$460	H
Additional pregnancies per 21 days	(C/100)*D	1.6	I
Additional value per 21 days	H*I	$718	J
Profit per 21-day period	J - G	$603	K
Gross profit per year	K*(365/21)	$10484	L
Cost of increased veterinary visits	Assumption – see text for details	$1080	M
Net economic gain	L - M	$9404	

The study population could be described as not being early adopters of synchronized breeding programs. However the results, including the responses of participating farmers at the end of the study, suggest that an initial incentive may assist this segment of the industry to implement a systematic reproduction management program.

Conclusions

Implementation of a simple but systematic timed insemination program to place upper limits on the intervals to first AI and to re-breeding in open cows, coupled with biweekly "herd check" visits by a veterinarian, resulted in a profitable improvement in herd

Table 4. Summary of the economic analysis (in Canadian dollars) of implementing a simple systematic reproduction management program in dairy herds, using two separate spreadsheets to estimate the economic benefit of improved herd pregnancy rate associated with the program, net of the costs for hormones and increased veterinary visits. See the text for assumptions and details.

					Method 1		Method 2	
Herd number	Herd size	PR start	PR end	PR change	Net herd annual	Net/cow	Net herd annual	Net/cow
39	175	11	7	-4	(-$45,064)	(-$258)	(-$24,086)	(-$138)
38	120	14	11	-3	(-$21,830)	(-$182)	(-$15,548)	(-$130)
3	95	14	11	-3	(-$15,255)	(-$161)	(-$11,064)	(-$116)
8	85	14	11	-3	(-$13,785)	(-$162)	(-$10,098)	(-$119)
34	65	12	10	-2	(-$10,754)	(-$165)	(-$8,589)	(-$132)
15	45	11	9	-2	(-$6,946)	(-$154)	(-$4,923)	(-$109)
5	72	15	15	0	(-$2,816)	(-$39)	(-$2,824)	(-$39)
7	50	14	15	1	(-$1,486)	(-$30)	(-$1,809)	(-$36)
35	60	11	12	1	(-$485)	(-$8)	(-$1,308)	(-$22)
2	124	10	12	2	$3,291	$27	(-$1,508)	(-$12)
18	70	12	14	2	$291	$4	(-$892)	(-$13)
9	70	11	13	2	$2,278	$33	$3	$0
10	95	15	17	2	$1,980	$21	$563	$6
37	130	9	11	2	$8,385	$64	$3,433	$26
25	50	11	14	3	$2,659	$53	$1,080	$22
29	70	14	17	3	$3,065	$44	$2,144	$31
21	30	11	15	4	$2,014	$67	$1,437	$48
31	30	14	18	4	$866	$29	$1,824	$61
13	45	8	12	4	$5,487	$122	$2,601	$58
19	60	10	14	4	$5,425	$90	$3,786	$63
6	80	10	14	4	$10,663	$133	$6,254	$78
14	130	9	13	4	$18,964	$146	$6,496	$50
28	185	11	15	4	$18,214	$98	$8,211	$44
16	65	14	19	5	$8,085	$124	$6,392	$98
32	60	11	17	6	$9,697	$162	$4,572	$76
33	50	11	17	6	$8,327	$167	$5,418	$108
23	45	11	17	6	$5,827	$129	$5,455	$121
30	65	11	17	6	$9,488	$146	$7,089	$109
17	68	9	15	6	$11,999	$176	$8,723	$128
20	70	13	19	6	$10,436	$149	$9,404	$134
26	110	13	19	6	$13,012	$118	$11,924	$108
27	210	11	17	6	$38,976	$186	$22,252	$106
22	36	8	15	7	$8,389	$233	$5,279	$147
12	65	13	20	7	$10,100	$155	$7,054	$109
1	40	14	22	8	$5,935	$148	$6,335	$158
4	52	11	19	8	$10,846	$209	$9,189	$177
36	80	9	17	8	$20,656	$258	$12,060	$151
24	30	11	21	10	$7,414	$247	$7,947	$265
11	55	11	21	10	$15,206	$276	$11,522	$209

PR in 72 to 77% of the herds, depending on the method of estimation of economic benefits. Among herds with initial PR between 8 and 15% and without a systematic insemination program, the results suggest that implementation of a simple reproductive management program is likely to increase PR by an average of 3 to 4 points.

Endnotes

[a]Valley Ag, Tulare, CA
[b]Lutalyse; Pfizer Animal Health, Kirkland, QC
[c]DS@HR, St. Hyacinthe, Quebec
[d]Microsoft Corporation, Redmond, WA
[e]SAS, Cary, NC

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