The Ovsynch Breeding Program for Dairy Cows – A Review and Economic Perspective

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Abstract

Heat detection is the single biggest impediment to improved reproductive performance in many dairy herds. Recently, a program for synchronization of ovulation ("Ovsynch") has been developed, which allows for breeding by scheduled artificial insemination. This paper reviews the literature on synchronization of ovulation in lactating dairy cows, and evaluates the economic impact of using the Ovsynch program. Ovsynch offers a method to reliably achieve timely pregnancies without heat detection initially. It increases the rate of insemination and allows control over time to first breeding, while having minimal impact on conception rate. In herds with poor or average heat detection, Ovsynch is economically beneficial as a first line reproductive management program for the herd.

Résumé

La détection des chaleurs est le plus grand obstacle à l'amélioration des performances de reproduction dans plusieurs troupeaux laitiers. Un programme de synchronisation de l'ovulation (« Ovsynch ») a été développé pour permettre la reproduction par insémination artificielle sur rendez-vous. Cette présentation revoit la littérature sur la synchronisation de l'ovulation chez les vaches laitières en lactation et évalue les retombées économiques de l'utilisation du programme Ovsynch. Le programme Ovsynch offre une méthode pour obtenir des gestations au moment voulu sans détecter les chaleurs initialement. La méthode améliore le taux d'insémination et permet un contrôle de la période de temps jusqu'à la première insémination tout en ayant une influence minimale sur le taux de conception. Chez les troupeaux où la détection des chaleurs est difficile ou moyenne, le programme Ovsynch est économiquement viable comme première étape dans le programme de gestion de la reproduction dans le troupeau.

Introduction

Reproduction is a critical element of dairy production, and reproductive management is the cornerstone of most veterinary herd health activities. Despite efforts by producers and veterinarians, maintenance of reproductive efficiency is an ongoing challenge on most dairy farms. Nutrition, body condition, metabolic disease, uterine disease and design of facilities influence reproductive efficiency, however, heat detection is the single weakest link in the chain.[24]

Recently, a program for synchronization of ovulation ("Ovsynch") and scheduled artificial insemination (AI) without heat detection has been developed which results in acceptable conception rates.[19] Many veterinarians and dairy producers have used the Ovsynch program on a limited basis. The objective of this article is to review key information and new data about Ovsynch, and to examine the economics of using Ovsynch as a whole herd program.

Monitoring Reproductive Performance

Calving interval and reproductive cull rate are useful parameters to understand the concepts of reproductive performance on dairies, however their usefulness for monitoring reproductive performance is limited.[7,18,31] If calculated regularly, pregnancy rate can provide a current, inclusive measurement of reproductive performance.

Terminology[7]

➢ Heat Detection Rate (HDR) – the proportion of eligible cows that are detected in heat or bred in a 21 day period (1 estrus cycle).

Conception Rate (CR) – the proportion of inseminated cows that are diagnosed pregnant after that breeding.

Pregnancy Rate (PR) – the proportion of open cows that become pregnant in a 21 day period. PR = HDR x CR.

Note that HDR and PR are rates, incorporating the element of time, and therefore reflect the speed at which cows are inseminated and become pregnant (Figure 1).

It has been generally accepted that a typical dairy farm has 50% HDR and 50% CR, which may be overly optimistic. A 1998 summary of 2500 herds on Dairy Herd Improvement (DHI) in Minnesota showed an average HDR of 35%, CR of 36% and PR of 12% (Steve Stewart, personal communication). A similar analysis of 1999-2000 data from 2279 dairy herds on DHI in Ontario revealed an average HDR of 35%, while the average CR and PR were 44% and 14%, respectively (David Kelton, personal communication).

The Ovsynch Program

Field studies have consistently shown that herd-based reproductive management programs where groups of cows are systematically synchronized for heat detection outperform programs utilizing individual cow heat detection, with or without use of reproductive hormones.[2,14,16] All reproductive management programs available in Canada and the US prior to Ovsynch augmented, but still required heat detection. Earlier timed insemination programs did not achieve viable conception rates.[21,27] Consequently, Ovsynch is the most significant development in dairy cattle reproduction management since prostaglandin became available in the early 1980's.

The basic Ovsynch protocol (Figure 2) has been well described and evaluated in field trials.[2,3,12,19,21,22,28,29] Several reviews have been published.[15,25,26,32] The program exploits recent improvements in understanding follicular dynamics in cattle, and the ability of gonadotropin-releasing hormone (GnRH) to modulate this process.[11,33] Briefly, the first injection of GnRH causes ovulation or induces regression of an early (first or second) wave dominant follicle, which results in a new, synchronized wave of follicular growth. One week after GnRH administration, injection of prostaglandin F2α (PGF) causes luteolysis and allows the newly selected dominant follicle to mature toward ovulation. The second dose of GnRH causes ovulation of the mature follicle 24 to 32 hours later.[19] When started at a random stage of the estrus cycle, approximately 85% of cows will have a synchronized ovulation.[8,19,35] Approximately 9% of cows will demonstrate spontaneous estrus during the course of the program.[29] It is important to understand that cows on Ovsynch ovulate prior to full estrus behavior, therefore managers should not wait for signs of heat before insemination. Conversely, cows that do demonstrate standing heat during the course of the protocol should be inseminated, because these cows have not been successfully synchronized.[32]

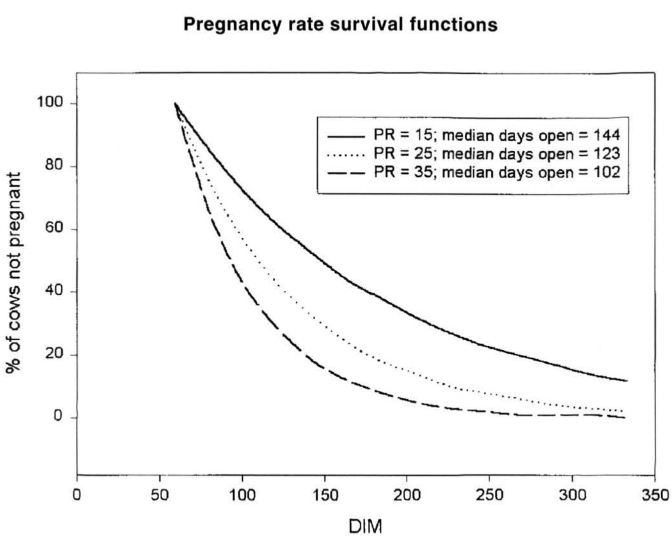

Figure 1. Pregnancy rate (PR) reflects the speed at which cows become pregnant after the voluntary waiting period (VWP). In this example VWP = 60 days. Pregnancy rate = heat detection rate x conception rate.

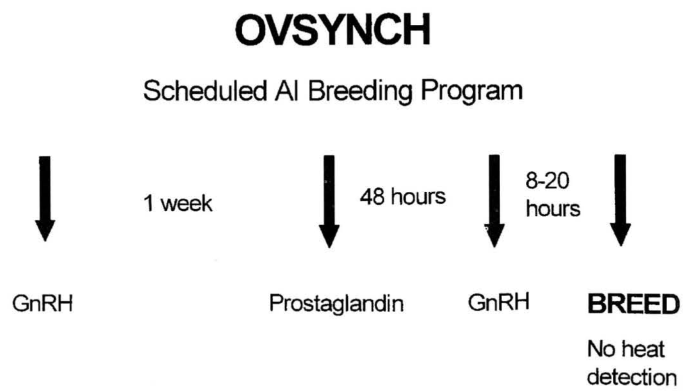

Figure 2. Ovsynch – a program for synchronization of ovulation and timed insemination in lactating dairy cows.

Ovsynch depends on modulating the follicular wave cycle. Heifers exhibit different follicular dynamics than lactating cows.[21] For this reason, Ovsynch in its current form does not produce acceptable rates of synchronization or pregnancy in heifers, and should not be used in these animals.

The key feature of Ovsynch is the increase in the insemination rate, with minimal impact on conception rate. By definition, all cows enrolled in the program are inseminated. As a result, there is complete control over time to first service, and time from diagnosis of non-pregnancy to re-breeding. Under midwestern US conditions, the first service conception rate with Ovsynch (36-39%) is equal to[21,22] or somewhat less than the conception rate to detected heat (36 and 41% conception rate for Ovsynch and heat detection, respectively).[29]

However, the insemination rate (effective heat detection rate) with Ovsynch is 100% within the cycle in which it is administered, therefore the pregnancy rate with Ovsynch (36-39%) is consistently higher than with heat detection, with or without heat synchronization.[12,21,22,29] Under conditions of heat stress (e.g. Florida), the absolute conception and pregnancy rates are lower than in temperate climates, but the use of Ovsynch results in pregnancy rates comparable to[3] or superior to[25,26] breeding on detected heats.

In a split-herd trial, cows in the Ovsynch group were bred exclusively without heat detection, while cows in the control group were bred based on detected heat.[22] Conception rates at first, second and third service were comparable between Ovsynch and heat detection groups. There is no apparent contraindication to repeated resynchronization with Ovsynch. Furthermore, more cows managed with Ovsynch were pregnant sooner than cows in the heat detection group (53% vs. 35% pregnant by 100 days-in-milk (DIM)). If ultrasound is used 4 weeks after breeding to identify non-pregnant cows, it may be possible to eliminate heat detection entirely. The feasibility of this option, particularly in small and medium size herds, remains to be quantified.[4] For herds with average heat detection intensity and pregnancy diagnosis based on rectal palpation at 35-45 days, overall reproductive performance will likely be optimized by using Ovsynch for all first inseminations, followed by intensive heat detection 3 weeks later to re-breed cows returning to estrus. Cows diagnosed non-pregnant should be promptly re-enrolled on Ovsynch. In herds where heat detection intensity is poor (<30%), complete elimination of heat-based breeding in favor of Ovsynch for all services may improve pregnancy rate, despite the delay in re-breeding until after pregnancy diagnosis.

Fine-Tuning Ovsynch

Altering the timing

Interval between first GnRH and PGF. Published research suggests that an interval of 6 or 7 days is likely to successfully synchronize a new follicular wave.[33] However, the 7 day interval is the standard, which has been extensively tested in field trials. Furthermore, the weekly interval is conducive to routinely scheduled implementation.

Interval between PGF and second GnRH. The standard is 48 hours, however intervals of 30 to 48 h have been investigated and used successfully.[21,22,28,29] Indirect evidence suggests that an interval of 48 h may produce a higher conception rate than a 33 h interval.[29]

Interval between second GnRH and AI. Intervals of 0 to 32 hours have been field-tested.[23] Ovulation occurs 24-32 h after administration of GnRH, and the ovum is viable for approximately 8 h post-ovulation. Sperm are viable for ≥ 24 h after deposition, but require 8-10 h to undergo capacitation. Evidence suggests that the optimal time for timed insemination after Ovsynch is approximately 16 h after the second administration of GnRH.[20] However, intervals of 0-24 h can produce acceptable conception rates. Delaying breeding until 32 h after administration of GnRH is not recommended due to a significantly reduced conception rate.[23]

The effect of varying the time from GnRH administration to insemination on pregnancy loss and the gender ratio of calves has also been investigated (Table 1).[23] These results should be interpreted with caution because the statistical power of this study was limited. The rate of pregnancy loss between diagnosis by ultrasound and calving was high, but consistent with other studies.[35] This apparent high rate of fetal wastage does not appear to be a function of Ovsynch, but rather reflects detection of more (ill-fated) pregnancies at an earlier stage when ultrasound is used to diagnose pregnancy as early as 24 d post breeding. Additionally, a follow-up study showed no difference in pregnancy loss between cows bred at 0 or 24 h after the second dose of GnRH was given.[34]

When to Start Ovsynch

Stage of lactation. Two field studies have demonstrated higher conception rates when Ovsynch breedings occur after 75 DIM, as compared to 50-75 DIM (43-47% vs. 36-39%, respectively).[21,23] The reason for this difference is not evident, since in both trials the conception rate in the control group (bred based upon heat detection) was essentially stable across these time periods. The additional time between calving and breeding may allow a greater proportion of cows to be fully cyclic, and therefore more responsive to Ovsynch. The conventional voluntary waiting period (VWP) between calving and insemination may not be applicable to the Ovsynch breeding program. The biological minimum to allow for complete involution of the uterus is 40 days following calving. For a theoretical ideal calving interval of 12 months, cows should become pregnant at 85 DIM. Therefore, a VWP of 50-60 days does not represent a biological or economic target, but rather reflects the inefficiency of heat detection in typical herds. With all first services by Ovsynch, the interval to first service can be precisely controlled for any number of cows. Therefore, cows should be synchronized to be bred at 75-80 DIM, thereby taking advantage of the higher conception rate, as well as achieving a profitable calving interval for those cows conceiving on first service.

Stage of the estrus cycle. When Ovsynch is initiated at a random stage of the estrus cycle, the overall rate of synchronization of ovulation (measured by ultrasound) is 83 – 85%.[8,19] However, there must be a re-

Table 1. The effect of altering the interval from the second injection of GnRH to AI breeding in an Ovsynch protocol.

	Interval from second GnRH to AI					
Hours	**0**	**8**	**16**	**24**	**32**	**Total**
n	149	148	149	143	143	732
Conception rate (%)[1]	37	41	45	41	32	39
Pregnancy loss (%)[2]	9	21	21	21	32	22
Calving rate (%)[3]	34	32	36	33	22	31
Heifer: Bull ratio[4]	61:39	45:55	54:46	54:46	65:35	55:45
Breedings yielding a heifer calf (%)[5]	19	14	18	16	13	17

Adapted from Pursley *et al,* 1998[23]
[1]The number of cows diagnosed pregnant by ultrasound at 25-35 days after breeding divided by the number bred
[2]The number of cows diagnosed pregnant that were subsequently diagnosed open divided by number diagnosed pregnant
[3]The number of cows that calved divided by the number bred
[4]The ratio of female to male calves born
[5]The proportion of female calves born multiplied by the calving rate
These results should be interpreted with caution because the statistical power of this study was limited.

sponsive corpus luteum present at the time of administration of prostaglandin for the program to work as intended,[13] and there must be emergence of a new follicular wave following the first injection of GnRH. Accordingly, the highest rate of successful synchronization occurs when cows are between days 1 and 12 of the cycle (post-estrus) when Ovsynch is started.[35] Cows started on days 5 to 9 almost universally ovulate in response to the first GnRH injection, and cows that ovulate after the first GnRH injection are more likely to have a subsequent synchronized ovulation than cows that do not ovulate.[35] Moreover, conception rate is higher and pregnancy loss tended to be lower in cows that started Ovsynch on days 5 to 13 of the cycle. Therefore, Ovsynch is ideally initiated when cows are in mid-cycle.

Reproductive performance may be improved with more precise timing of initiation of Ovsynch. However, attempts to monitor or manage the ovarian status of individual cows defeats the purpose and power of a systematic breeding program. Attempts have been made to systematically "set-up" cows prior to enrollment on Ovsynch. Synchronization with prostaglandin prior to Ovsynch has been termed "Pre-Synch". In two experiments, two injections of prostaglandin were given 14 days apart; the second injection was administered 12 days prior to the start of Ovsynch. This pre-synchronization increased conception rate by 11 to 13 percentage points, as compared to Ovsynch alone (42.8 vs. 29.3%, and 46 vs. 34.9%, respectively).[30] The mechanism for this improvement, as well as the economic benefit, remains to be assessed.

Practice Tips When Implementing Ovsynch

Match the size of groups to be synchronized with facilities for breeding and calving.
Thaw a maximum of 2 straws of semen at a time when breeding multiple cows at once.
Emphasize proper storage and handling of hormones (e.g. refrigeration of GnRH).
Emphasize a clean needle policy for all injections.
Avoid injections in the parlor.

Ovsynch and Cystic Cows

Two recent studies have evaluated the use of Ovsynch on cows diagnosed with cystic ovarian structures. In a Wisconsin study, 26 of 237 cows enrolled on Ovsynch were diagnosed as cystic at the time of enrollment.[9] The conception rate tended to be lower in cystic than in non-cystic cows (27% vs. 41%). In a Florida study started at 65 DIM, 209 non-cystic and 76 cystic cows were enrolled on Ovsynch, while another 83 cystic cows were treated with GnRH, followed by PGF 7 d later, and bred based on detected estrus.[1] Cystic cows had lower PR than non-cystic cows. Among cystic cows, CR was higher in the estrus detection group, but PR was similar between treatments. While cystic ovarian condition may reduce fertility in the short term, the Ovsynch program produces comparable PR to a program where cows are treated with GnRH/PGF and then bred based on heat detection. Therefore, there does not appear to be any advantage to excluding cystic cows by examination prior to enrollment when Ovsynch is used to synchronize all cows for first service.

Reducing the Dose of GnRH

A field trial was conducted on 237 cows in one herd to compare using 50 μg (half-dose) to 100 μg (standard dose) of GnRH[a] within a standard Ovsynch protocol. The rates of ovulation (83.1% and 84.9%, respectively) and pregnancy at 56 d post-insemination (35.1% and 33.6%, respectively) were not different between the two groups.[8] Reducing the dose of GnRH reduced the cost of Ovsynch by $6.40 (US) per cow or $20.27 (US) per pregnancy, assuming a retail cost of $6.40 (US) per 100 μg of GnRH. The cost of GnRH in Canada is not the same as in the US; the current retail cost of GnRH in Ontario is approximately $3.60 (CDN)/dose (equivalent to $2.35 US at the current exchange rate of $1 US = $0.65 CDN). As a result, the cost savings from using a reduced dose of GnRH is less compelling in the Canadian market ($3.60 [CDN] per cow or $11.92 [CDN] per pregnancy). A recent study of 494 beef cattle bred by Ovsynch using either 50 or 100 μg GnRH demonstrated a significantly reduced conception rate in cows that received the lower dose of GnRH (32% versus 42% CR, respectively).[10]

Putting Ovsynch in an Economic Context

Profitability of dairy farms is partially dependent upon consistently getting cows pregnant on a timely basis. The level and persistency of milk production, milk price, cow age, health and genetic merit influence individual and herd reproductive optima.[5,17] Conceptually, profit is maximized when cows spend more of their life in productive days in early lactation, and animals are replaced according to future profitability.

There are direct costs associated with reproductive inefficiency, such as increased semen cost and greater costs for reproductive management tools, such as labor, hormones, heat detection aids and veterinary examinations. The greatest cost, however, is the income lost because of milking cows later into the less profitable part of their lactation cycle. This opportunity cost may not be immediately obvious to producers since there is no direct cash outlay.

The economic return for improved reproductive performance comes not when a cow becomes pregnant, but through timely subsequent calving, which allows cows to spend a greater proportion of their lifetime in earlier lactation. The economic reward is paid through improved profit per cow per year. If a herd has a high incidence of peripartum disease or a high risk of culling of pregnant cows, then the economic benefit of improved reproduction would have to be discounted. However, such a situation should motivate improved transition cow management, not discourage better reproductive management.

Economic modeling studies have repeatedly shown that profitability is maximized when cows calve at 12 month intervals, and at least 85% of cows that are selected for re-breeding subsequently calve again.[5,6,7] This target is only moderately sensitive to the level of milk production.[5,6,17] Achievement of this goal would require that 85% of cows are pregnant by 85 DIM, which is not a realistic goal for most dairy herds. However, there are economic rewards for moving as close as practical to this goal.

If 13 months is a realistic target for the calving interval, cows must be pregnant by 115 DIM, leaving 65 days in which to get pregnant (395 days [13 months] – 280 days gestation – 50 days for uterine involution = 65 days to get pregnant). Given a 21 day estrus cycle, 65 days represents only three heats for most cows. Therefore if all cows are to calve every 13 months, one-third of open cows must become pregnant in each of the three available cycles, i.e., a 33% pregnancy rate. Similarly, economic modeling by Ferguson and Galligan at the University of Pennsylvania has shown that income per cow per year is optimized at a pregnancy rate of 35%.[7]

In order to approach these targets, a diligent, systematic program for reproductive management must be followed. Modeling of reproductive performance has demonstrated that the single greatest determinant of calving interval is the first service heat detection rate.[7] Implementation of Ovsynch for all first inseminations of lactating cows ensures that all cows are inseminated within a precise window of time, as dictated by management decision.

Monitoring the Success of an Ovsynch Program

Pregnancy rates of 30 to 40% are typically reported for the Ovsynch program. These figures, while correct in themselves, represent one cohort of cows followed for a single breeding cycle. When Ovsynch is systematically implemented in a herd, a pregnancy rate of 35%, while an ideal goal, is not realistic over the medium or long term. Table 2 illustrates a more realistic calculation of herd PR over time. In this example, heat detection is eliminated, but early pregnancy diagnosis allows all open cows to be re-synchronized 42 days (on average) after breeding. With heat detection, more open cows will be re-bred in the first cycle after insemination, but with bi-weekly or monthly pregnancy diagnosis, additional lag will be introduced to identify open cows not seen in heat. In the example, a hypothetical cohort of

[a]Cystorelin®, Merial Limited, Iselin, NJ 08803

Table 2. Cumulative heat detection and pregnancy rates over multiple heat cycles in a hypothetical cohort of 100 cows bred exclusively with Ovsynch.

Conception Rate = 40%						
21 day cycle number	**Number heat eligible**	**Heat detection (insemination) rate**	**Number bred**	**Number pregnancy eligible**	**Number pregnant**	**Pregnancy rate**
1	100	100	100	100	40	40
2	60	0	0	60	0	0
3	60	100	60	60	24	40
4	36	0	0	36	0	0
5	36	100	36	36	14	40
6	22	0	0	22	0	0
7	22	100	22	22	9	40
8	13	0	0	13	0	0
9	13	100	13	13	5	40
10	8	0	0	8	0	0
Total	370		231		92	
Average		62%				25%

This table illustrates a cohort of 100 cows at the end of the voluntary waiting period. All cows are bred exclusively on the Ovsynch program. The breeding period lasts for 210 days (10 cycles of 21 days).

Assumptions: 1) The conception rate is 40% for all inseminations, 2) heat detection is eliminated completely, and 3) pregnancy diagnosis is performed 32 days after insemination and open cows are re-enrolled on the Ovsynch program, resulting in an inter-insemination interval of 42 days. Because no heat detection is performed, cows are re-bred only after being diagnosed non-pregnant. Therefore, pregnancies occur only in alternate periods of 21 days.

Even with wholesale adoption of the Ovsynch program and early pregnancy diagnosis, achievement of a herd average pregnancy rate > 35 % in lactating cows is not realistic over the long term.

100 cows is followed over time. In a whole herd, the situation is more complex because new animals enter the breeding period each week, while others will be culled or flagged for no further breeding.

It is important to set realistic goals to assess the effectiveness of an Ovsynch program. Conception rate should be between 37 and 47%. If it is consistently less than 40%, protocol adherence, handling of the hormones, semen handling and AI technique should be evaluated. Additionally, broader investigation of nutrition, body condition and the incidence of peripartum disease may be warranted. As illustrated (Table 2), even with full-scale implementation of Ovsynch, the herd average heat detection rate will not be 100% over time; HDR >60% should be targeted. If repeat services are based on a combination of heat detection and re-synchronization of open cows, the HDR should be ≥ 50%. If Ovsynch is used for all first breedings and a combination of heat detection and Ovsynch is used for repeat services, a herd pregnancy rate of 18 to 22% is a realistic goal. Aggressive use of Ovsynch coupled with early pregnancy diagnosis could allow the pregnancy rate to approach 25% (Table 2). Given the reproductive performance in many dairy herds, these targets represent a significant improvement in reproductive efficiency and potential profitability.

The proportion of cows pregnant at pregnancy examination is not an appropriate tool to monitor the success of implementation of an Ovsynch program (Table 3). The proportion of cows pregnant at pregnancy examination is an indirect measure of the intensity of heat detection, and does not reflect PR in the short term. Only if heat detection is completely abandoned in favor of Ovsynch will this proportion reflect PR.

The Economics of Ovsynch as a First Line Herd Program

Modeling of reproductive performance suggests that the single largest determinant of calving interval (CI) is first service HDR, accounting for 42% of the variability in performance.[7] In other words, the speed

Table 3. The proportion of cows pregnant at pregnancy diagnosis does not reflect pregnancy rate in the short term.

	Reproductive management program and level of heat detection				
	Outstanding heat detection	Good heat detection	Average heat detection	Ovsynch with post-breeding heat detection	Ovsynch without post-breeding heat detection
n	10	10	10	10	10
Heat detection rate (%)	80	50	40	100, 40	100, 0
Number bred in first cycle	8	5	4	10	10
Conception rate (%)	50	50	40	40	40
Number returning to heat	4	2	2	6	6
Number detected in heat in second cycle and re-bred	3	1	0	2	0
Number for pregnancy Dx	5	4	4	8	10
Number pregnant	4	3	2	4	4
Number open	1	1	2	4	6
% open at preg check	20	25	50	50	60
Pregnancy rate, 1 cycle (%)	40	25	16	40	40

This illustrates hypothetical cohorts of 10 cows followed for 2 estrus cycles.

The proportion of cows pregnant at pregnancy diagnosis is an indirect measure of the intensity of heat detection in a herd. In principle, cows that are inseminated but do not become pregnant should return to estrus approximately 21 days later, be detected in heat, and be re-inseminated. To the extent that this does not happen due to failure of heat detection, these open cows will be presented for pregnancy diagnosis and will contribute to a lower proportion of cows pregnant at the time of pregnancy diagnosis. The proportion of cows pregnant at pregnancy diagnosis is not an accurate measure of the success of implementation of an Ovsynch program. For example, with the average heat detection scenario or the Ovsynch with post-breeding heat detection scenario, 50% of cows are open at pregnancy diagnosis. In the former scenario, 2 of the original 10 cows are pregnant, but in the latter scenario, 4 of 10 cows are pregnant.

at which cows are inseminated once past the herd's VWP has a large influence on time to pregnancy, more than the conception rate (accounting for 24% of the variation in CI), or the length of the VWP (accounting for 25% of the variation in CI).[7] Therefore, in herds with anything less than outstanding heat detection (HDR > 60%), there is a compelling case to use Ovsynch systematically for all first inseminations of lactating cows.[7] In this way, all cows can be bred promptly and in a precise time interval as dictated by a management decision. No cows should fail to be inseminated in a timely way when Ovsynch is used.

When cows are pregnancy checked weekly at the earliest practical stage (ultrasound at 25-35 d, or palpation > 35 d), open cows can promptly be resynchronized and re-bred 10 d after being diagnosed non-pregnant. With this scenario, heat detection could plausibly be eliminated. Under the management conditions of small to medium sized dairy herds, such intensive pregnancy diagnosis is generally not practical. Therefore, a combination of heat detection 3 weeks after initial Ovsynch breeding, coupled with prompt, automatic re-synchronization of cows found open at pregnancy check, is likely to optimize reproductive performance. This is particularly true when there is reliance on secondary signs of estrus (e.g. tie stall barns when there is no opportunity to show standing heat). If heat detection accuracy or intensity is poor (HDR < 30%), attempts to re-breed open cows returning to heat will delay definitive pregnancy diagnosis and re-enrollment in the program.

Generally, Ovsynch produces more pregnancies, and increases the proportion of cows pregnant by 120 DIM, as compared to reproductive management that relies on heat detection. Figure 3 and Table 4 depict two simulated cohorts of 100 cows to compare the reproductive and economic performance of exclusive use of Ovsynch to performance with conventional heat de-

Survival curves for days to pregnancy with two breeding programs.

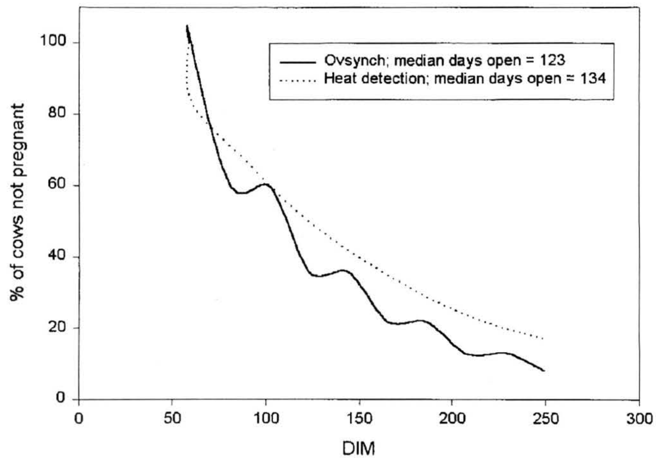

Figure 3. The cumulative distribution of pregnancies in 2 hypothetical cohorts of cows managed with Ovsynch or conventional heat detection with occasional use of prostaglandin.

Assumptions: (1) VWP = 50 days with heat detection and 71 days with Ovsynch; (2) conception rate = 40% in both groups; (3) no heat detection in the Ovsynch group; (4) early pregnancy diagnosis in both groups: Ovsynch cows that are open are re-bred (on average) 2 cycles (42 days) after the previous breeding. Open cows in the heat detection group that are not detected in heat and re-bred in the first cycle after insemination will be diagnosed open in the next cycle, and continue to have a 40% probability per cycle of being bred.

tection with periodic use of prostaglandin. This illustration is designed to contrast the Ovsynch program with no post-breeding heat detection to a scenario of above average heat detection with minimal input of reproductive hormones. Despite a delay in initiation of breeding under Ovsynch, more cows are pregnant by 125 DIM and at 250 DIM. This has economic value, by increasing the proportion of cows that approach the economic target of CI less than 13 months. Numerous studies have attempted to quantify the opportunity cost of additional days open beyond the economic optimum. Most estimates center on $2-3 (US) for each day a cow is open past 100-120 DIM. However these calculations often do not include the economic cost of culling otherwise meritorious cows due to their inability to become pregnant again. Recently, Canadian workers have developed and validated a new, single index to estimate the economic cost of reproductive inefficiency.[17] Adjusted Calving Interval (ACI) incorporates both days open and reproductive culling rate into a measure of cost relative to the theoretical ideal 12 month calving interval. They estimate an opportunity cost of $3.05 (US)/cow/day of ACI. The value of this index is relatively insensitive to the price of milk, replacements, cull cows and feed. While the exact value may vary between herds, the example illustrates a comparison of relative economic benefit of two programs within a hypothetical herd.

The example in Table 4 (page 21) uses a conservative estimate of the cost of reproductive hormones in the heat detection group, and initiates breeding one cycle (21 d) earlier under the heat detection scenario than with the Ovsynch program. It is assumed that the full 100 µg dose of GnRH is used for both injections, giving a cost of $16.10 (US) each time Ovsynch is administered. Despite these assumptions and the greater cost of hormones and semen when using Ovsynch, there is a net economic benefit of $106 (US)/cow. If the dose of GnRH is reduced to 50 µg, assuming no change in CR, the net benefit of Ovsynch is $119 (US)/cow. Using Canadian hormone and ACI costs and the 100 µg dose of GnRH, there is a net economic benefit of $195 (CDN)/cow for the Ovsynch program. This illustrates the significant profit potential with extensive use of Ovsynch in herds with average PR.

Conclusion

The Ovsynch program is a useful tool to improve reproductive performance and profitability in lactating dairy cows. However, reproductive performance needs to be monitored accurately by regular calculation of pregnancy rate, and targets of performance must be realistic. The Ovsynch program should be considered for all first inseminations in many dairy herds, and for repeat breedings in herds with average or below-average heat detection.

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Table 4. Economic benefit of Ovsynch compared to above-average heat detection (reproductive performance from Figure 3). All figures in US dollars.

	Ovsynch No heat detection VWP[1] = 71 days	Heat Detection Periodic PGF VWP = 50 days
Number of cows	100	100
Heat detection rate (%)	62	40
Conception rate (%)	40	40
Pregnancy rate (%)	25	16
Number pregnant at 250 DIM	92	83
Total number of inseminations	231	207
Services/pregnancy (all cows)	2.3	2.1
Average days open (pregnant cows)	127	127
Median days open (all cows)	123	134
Number to be culled (open >250 d)	8	17
Adjusted calving interval (ACI) [2]	445	493
Costs		
Hormones[3]	$3,719	$330
Semen @ $25/insemination	$5,775	$5,175
Sub-total (cash costs)	$9,494	$5,505
Opportunity cost of ACI [4]	$135,725	$150,365
Difference in ACI cost		$14,640
Net economic cost	$9,494	$20,145
Net difference		$10,651
Net difference/cow		$106

[1]VWP = Voluntary waiting period (the interval from calving until a cow is eligible to be bred).

[2]ACI = $\frac{\text{Projected calving interval for pregnant cows in days}}{1 - \text{(rate of culling for reproductive failure)}}$ Plazier et al 1997[17]

[3]Retail prices: Prostaglandin = $3.30/dose, GnRH = $6.40/100 μg. Assumes full 100 μg dose of GnRH in the Ovsynch program. Based on only 1 injection of PGF per cow per lactation in the heat detection group.

[4]Cost per additional day of ACI = $3.05/cow/day, calculated by Plazier et al 1997.[17]

Assumptions: 1) equal conception rate of 40% on either program, 2) early pregnancy diagnosis in both groups: Ovsynch cows that are open are re-bred (on average) 2 cycles (42 days) after the previous breeding. Open cows in the heat detection group that are not detected in heat and re-bred in the first cycle after insemination will be diagnosed open in the next cycle, and continue to have a 40% probability per cycle of being bred, and 3) No heat detection in the Ovsynch group.

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Temporal aspects of the epidemic of bovine spongiform encephalopathy in Great Britain: individual animal-associated risk factors for the disease

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Veterinary Record (2000) 147, 349-354

The objectives of this study were first to determine the cumulative incidence of bovine spongiform encephalopathy (BSE) in the British cattle population from July 1986 to June 1997, secondly, to identify individual animal-associated risk factors that influenced the age of onset of clinical signs in confirmed BSE cases, and, thirdly, to assess the effectiveness of the measures introduced to control BSE during the epidemic. The analyses were based on the population of British cattle at risk, derived from agricultural census data collected between 1986 and 1996, and BSE case data collected up to June 30, 1997. The unit of interest was individual adult cattle recorded on annual agricultural censuses between June 1986 and June 1996. Univariate and multivariate survival analysis techniques were used to characterise the age of onset of clinical signs. In total 167,366 cases of BSE were diagnosed in Great Britain up to June 30, 1997. The cumulative incidence of BSE between July 1986 and June 1997 was 1·10 (95 per cent confidence interval [CI] 1·09 to 1·10) cases per 100 adult cattle at risk. Cattle from the South east, South west and Eastern regions of England had 4·26 to 5·96 (95 per cent a 4·15 to 6·14) times as great a monthly hazard of being confirmed with BSE as cattle from Scotland. Compared with cattle born before June 1985, those born between July 1987 and June 1988 had 22·5 (95 per cent CI 22·1 to 22·8) times the monthly hazard of being confirmed with BSE, whereas those born in the 12 months after July 1988 had only 7·39 (95 per cent CI 7·24 to 7·54) times the monthly hazard of being confirmed with BSE. This reduction in hazard was directly attributable to the ban on the use of ruminant protein as a feed instituted in July 1988. Successive cohorts from 1989 to 1991 experienced further reductions in the hazard of experiencing BSE. The additional decrease in hazard observed for the 1990 cohort may be attributed to the effect of the Specified Bovine Offal ban instituted in September 1990.