ECONOMIC IMPACT OF SYSTEMATIC BREEDING PROGRAMS AND FACTORS TO CONSIDER IN PROGRAM SELECTION FOR THE REPRODUCTIVE MANAGEMENT OF DAIRY CATTLE

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Introduction

Artificial insemination (AI) has been important in reducing disease transmission, allowing for genetic selection, and ultimately increasing the health, longevity, and milk yield of dairy cattle. However, increasing milk yield, dependence on human labor for the detection of estrus, and increased herd size have combined to furnish an environment that challenges the ability of management to maintain an acceptable level of reproductive performance. Reproductive efficiency is an important management component that directly and indirectly influences the economic performance of the dairy operation. Direct effects of a successful reproductive program are first realized by increasing the likelihood of cows remaining in the herd. Indirect effects would include the effects of increased percentage of cow life spent in profitable milk, increased rate of replacements generated, and improved returned on other interventions by reducing competitive risk of removal (Galligan et al., 1993).

Traditional methods of visual heat detection followed by AI do not work well when cows are managed in large groups. Large herds require more time for heat detection, identification, sorting, insemination, and record keeping simply because there are more cows. The responsibility for reproduction also falls on employees (instead of the owner) who may be overwhelmed by the number of cows to be managed. In some herds, heat detection aids (tail chalk, patches, etc.) have replaced visual detection of estrus and cows are inseminated based on rubbed tail heads, activated tail patches or the appearance of vaginal mucous. Unfortunately, less definitive signs of estrus often lead to poorly timed inseminations and poorly timed inseminations lead to lower conception rates (Dalton et al., 2001). The misidentification of estrus may be a big problem in today’s herds. In a study using a research herd of 242 Holsteins, Sturman et al. (2000) reported that 19% of inseminations were performed on cows in the luteal phase or early phases of pregnancy. Inseminations of pregnant cows led to 17% embryonic loss.

Systematic breeding programs (SBP) are becoming popular because herds with poor heat detection rates can achieve lower intervals to first insemination and higher pregnancy rates when compared to cows inseminated via non-synchronized observed estrus. Dairy cows inseminated within a SBP; however, have a lower conception rate (CR) when compared to dairy cows inseminated at an observed estrus (Jobst et al., 2000).

Therefore, traditional reproductive indices such as services per conception and CR are often negatively affected when SBP management strategies are implemented. Interval to first service and overall pregnancy rate (PR) almost always improves when a SBP is implemented.

Table 1 stratifies the range in calving interval (CI) for DHI herds processed by DRMS (Raleigh, NC). Days to first service, heat detection efficiency and CR are the three components, dependant on the intensity of culling, that determine the CI. Herds that obtained a CI <14 months averaged <83 days to first service, ~50% heat detection efficiency (as measured by percent of heats observed), and CR >40% for first service (Table 1). It is interesting that CR at first service ranged from 40 to 47%. The variables that really determine the CI are days to first service and heat detection with heat detection having a strong influence on days to first service.

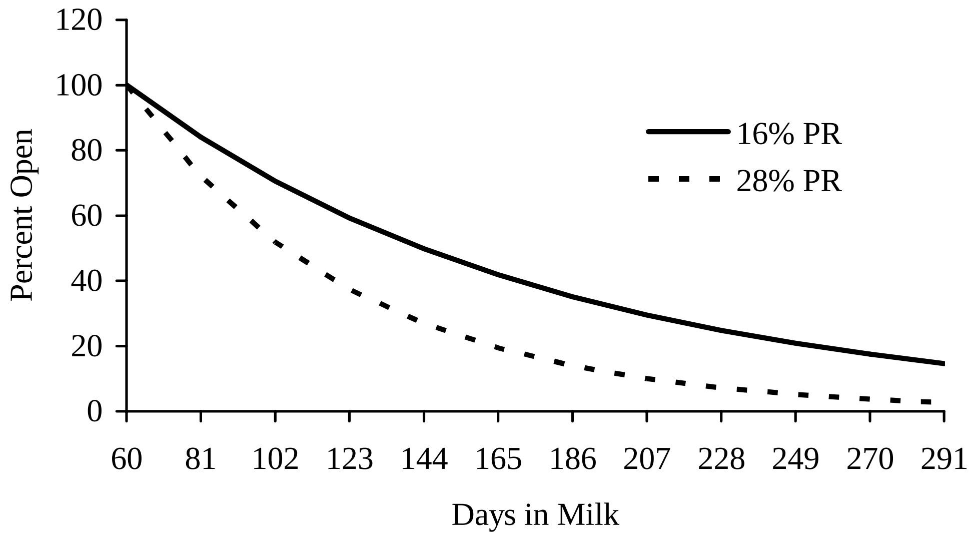
Table 1. Change in daily milk yield and reproductive performance for Holstein herds (n=4771) processed by DRMS and stratified by calving interval (DairyMetrics report for Holstein herds that had a 2X milking schedule with 25% or less of the services to non-AI sires).

	Calving Interval (months)					
Item	<13	13 to 13.9	14 to 14.9	15 to 15.9	16 to 16.9	>16.9
Number of herds	129	1416	1856	919	290	161
Daily milk yield (lbs)	66.5	67.1	64.2	60.3	57.3	53.5
Days to 1st service	74	82	93	105	120	140
CR 1st service	47	41	40	40	42	47
% heats observed	53	50	44	38	33	26

The PR, defined as heat detection or service rate times CR for the eligible cows every 21 days ultimately determines how fast cows become pregnant. Figure 1 contains the survival curve for two average PR, the 16% average PR is approximately the national average for dairy herds participating in DHI programs and the 28% average PR (slope of the curve) shows a lowering of the average days open by approximately two estrous cycles or 42 days in comparison to the 16% average PR curve. The economics of PR has been investigated by Oltenacu et al. (1981). Their data suggested that above 27.5% average PR there appears to be diminishing economic returns; thus, the marginal cost associated with achieving a higher PR exceeded the marginal benefits. However, their evaluations did not consider the potential of SBP and hence the cost associated with achieving a higher PR through improved heat detection was much higher. Marsh et al.

(1985) also reported economic returns of various PR with four different culling policies and, in general, gross margins per cow increased as PR increased.

Figure 1. Survival curves for a 16% average pregnancy rate compared to a 28% average pregnancy rate.

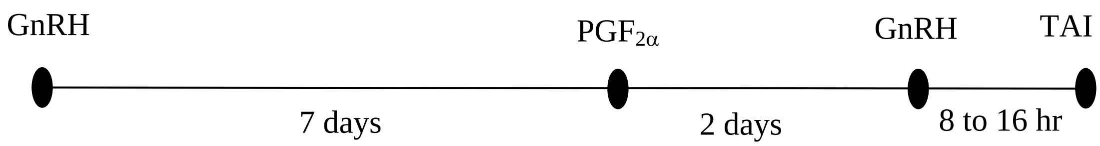


OvSynch®, PreSynch and HeatSynch™: Protocols for SBP

Synchronization of estrous behavior, through pharmacological control, has been used to improve reproductive efficiency since the late 1970's. Methods of synchronizing estrus were originally devised to decrease the time spent detecting estrus; however, SBP management strategies are now being used for convenience and efficiency in reproductive management. Moreover, the incorporation of a SBP should be based on a methodical approach for the entire herd rather than the individual cows to effectively influence reproductive performance and impact the income of the herd.

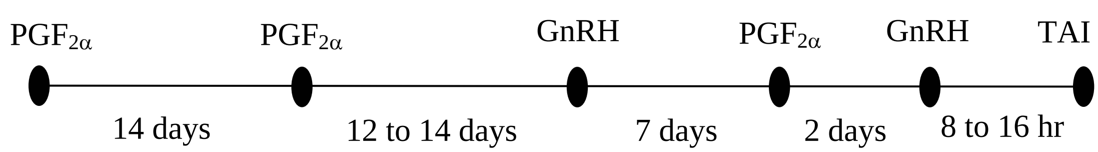
Basic research on the nature of follicular growth and atresia in cattle using transrectal ultrasonography resulted in the discovery of follicular waves (Savio et al., 1988 and Sirois and Fortune, 1988), each wave culminating with formation of a dominant follicle. The discovery of follicular waves made it clear that both follicular and luteal function must be controlled to accurately synchronize the estrous cycle and was the first step in the development of practical SBP management strategies. Estrus and (or) ovulation SBPs that regulated follicular development and luteal regression with GnRH and $PGF_{2\alpha}$ administered 7 days apart were established in the early 1990's (Thatcher et al., 1993; Wolfenson et al., 1994; Twagiramungu et al., 1995). The first SBP management strategy that resulted in CRs similar to those achieved with AI after a detected estrus was developed at the University of Wisconsin in 1995 (Pursley et al.) and is commonly referred to as OvSynch® because ovulation rather than estrus is synchronized. Figure 2 shows the protocol for hormone administration and insemination for the OvSynch® SBP.

Figure 2. The timeline used for hormone administration and AI in OvSynch® SBP.



The PreSynch SBP was designed to maximize the number of cows between Days 5 to 12 of the estrous cycle to increase the CR as compared to an OvSynch® SBP that is initiated at a random stage of the cycle. Vasconcelos et al. (1999) using lactating cows and Moreira et al. (2000) using dairy heifers reported that it is possible to manipulate the estrous cycle such that the majority of cows are in the ideal stage of the estrous cycle when the OvSynch SBP is initiated. Thus, the name Presynch was coined which is a SBP that administers two injections of $PGF_{2\alpha}$ 14 days apart with the second $PGF_{2\alpha}$ injection given 12 to 14 days before the initiation of OvSynch®. The Presynch SBP groups a high percentage of the cows into Days 5 to 12 of their estrous cycles when the first GnRH injection of OvSynch® is given as shown below in Figure 3.

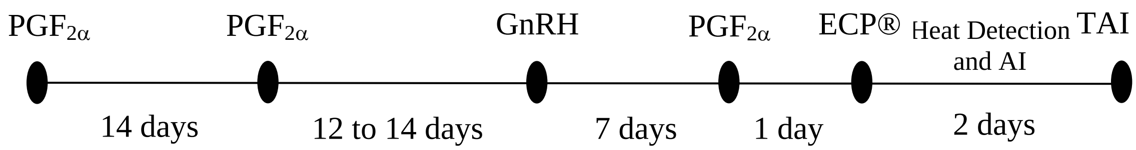
Figure 3. The timeline used for hormone administration and AI for PreSynch SBP.



Administration of two $PGF_{2\alpha}$ injections 14 days apart and 14 days prior to initial GnRH injection of OvSynch has become the accepted protocol of PreSynch because of management considerations. PreSynch is usually recommended for first postpartum AI because the duration of hormonal administrations to timed AI is 38 days.

The HeatSynch™ SBP was developed to utilize a relatively low cost commercially available estrogen (ECP®; Pfizer Animal Health, New York, NY) and requires heat detection in combination with timed AI of individuals not detected in estrus (Jordan et al., 2001 and Pancarci et al., 2002). There are two primary differences between PreSynch and HeatSynch (Figure 4): ECP® (1 mg) replaces GnRH at the last injection and ECP® is administered 24 hours after $PGF_{2\alpha}$ compared with 48 hours after GnRH. Timed AI occurs 48 hours after the ECP® injection for cows not identified in estrus and inseminated prior to the timed AI period.

Figure 4. The timeline used for hormone administration and AI with HeatSynch SBP.



Economic Impact of SBP Management Strategies: Costs of Days Open

Approximately 50% of the profit per lactation is generated in the first 100 days of lactation. During this period the return per feed dollar is usually 3:1 in contrast to late lactation when it is approximately 1:1. A goal of the reproductive management program should be to have the cow spend as much of her life in the early phase of lactation as possible. Thus, it is critical that the reproductive management program focus on getting a large percent of the cows pregnant quickly after the voluntary waiting period (VWP) so that the majority of the cows will spend a sufficient proportion of their lives in early lactation.

Pecsok et al. (1994a, b) derived equations and obtained estimate of financial benefits for various average PRs with interactions of milk yield, calving, culling for reproductive failure and days open. Improvement in milk production due to reduction in days open was dependent on days in milk, peak milk production, and monthly rate of decline in daily milk production. With equations derived by Pecsok et al. (1994a, b), we can calculate expected financial benefits from different strategies. Inputs used to compare average PRs due to SBP to average PRs due to a visual heat detection program only (with a 16% average PR) are found in Table 2. Costs per day open were calculated to be $0.50 for 100 days, $1.42 for 130 days, $2.99 for 160 days and $4.52 for 175 days.

Table 2. Inputs for spreadsheet calculation of cost per day open.

Mailbox Milk Price	13.23	$/cwt		
Feed Cost	0.07	$/lb DM	0.15	$/kg DM
Milk Price:Feed Cost	1.89	(Range 1.0-2.5)		
Heifer Cost	1200	$/head		
Cull Price	0.39	$/lb	0.86	$/kg
Heifer Cost:Cull Price	2.20	(Range 1.5-3.0)		
Milk Yield	65.0	lb/cow/day	29.5	kg/cow/day
Cull Yield	40.0	lb/cow/day	18.1	kg/cow/day
Days Open	160			
Do Not Breed	300			
Reproductive Losses	2.99	$/cow/d		

Inputs for the visual heat detection program were: a VWP was 60 days, “do not breed” set at 300 days, a 40% heat detection rate, and a 40% CR (16% average PR). Inputs for the OvSynch SBP were: average days to first service 75, “do not breed” at 300 days, a 40% synchronized CR (first post-VWP cycle), and a 33% CR for second and third synchronization cycles. The three synchronization cycles were followed by a visual heat detection that yielded an average 16% PR for the ensuing cycles. PreSynch SBP inputs were similar except first cycle CR was 40% compared to 33% for OvSynch®. The HeatSynch™ SBP differed with a 70% heat detection rate and 40% CR for heat detected services following ECP® administration with a 7% CR for timed AI services. For all three SBPs, heat detection was performed and cows inseminated between synchronization cycles with a visual heat detection that generated an average 16% PR for the visually-detected estrus periods. Importantly, the HeatSynch™ SBP calculations assumed no increased heat detection rate for potential breeding cycles between the synchronized cycles (a major benefit touted by this SBP’s proponents). For all four protocols, labor cost was $10 per hour with 5 minutes required per AI, semen cost was $15 per straw, and heat detection occurred for 60 minutes per day if utilized for the protocol in question. Pharmaceutical costs used in the spreadsheet were $2.50 for $PGF_{2\alpha}$, $2.25 for GnRH, $0.50 for ECP® and 2 minutes for labor per hormone injection.

Table 3 includes a comparison of the visual heat detection program (16% average PR) with three commonly used SBPs. Unadjusted cost per pregnancy (out of pocket cost) was lowest for the visual heat detection program at $55.40 with the three SBPs ranging from $78.59 for PreSynch to $69.87 for HeatSynch™. The number of reproductive culls showed an advantage to the synchronization protocols with visual heat detection resulting in a 14.8% cull rate or 37 of the 250 cows not pregnant by 300 days in milk. In contrast, the three SBPs had a similar culling rate of 6.4% or 16 of the 250 original cows failing to conceive by 300 days in milk. The adjusted cost per pregnancy which included cost of extended days in milk and cows removed because of failure to conceive by 300 days was $298.35 for the visual heat detection program, $123.46 for HeatSynch™, $115.39 for OvSynch® and $110.49 for each pregnancy obtained using the PreSynch SP.

Table 3. Comparison of Systematic timed AI programs for a herd of 250 lactating cows using costs per day open as the descriptive variable and heat detection prior to resynchronization with timed AI 43 days following previous service.

	Systematic timed AI programs			
	Visual (16% PR)	OvSynch	PreSynch	HeatSynch
Annual Cost, $	11,801	17,221	18,507	16,169
Unadjusted Cost, $ per pregnancy	55.40	73.66	78.59	69.87
Number of reproductive culls	37	16	15	19
Average days open	162	122	116	126
Cost per day open beyond 85 DIM	3.16	1.16	1.02	1.30
Adjusted cost, $ per pregnancy	298.35	115.39	110.49	123.46

Drug costs used were \$2.50 for $PGF_{2\alpha}$, \$2.25 for GnRH, \$0.50 for ECP. Labor cost was \$10 per hour with 60 minutes of labor required for heat detection. Inputs utilized were a maximum of 3 synchronization cycles followed by visual heat detection and 75 average days to first service and 300 days to do not breed with a \$15 semen price.

If visual heat detection is not used between synchronization cycles the average days open increases approximately 30 days for each synchronization protocol. The adjusted cost per pregnancy almost doubles for each SBP to \$280.66 for HeatSynch™, \$236.81 for OvSynch®, and \$199.26 for PreSynch. If there is no increase in first cycle PR with PreSynch, this protocol loses it economic advantage and OvSynch® has a slightly lower adjusted cost per pregnancy because of the absence of the two set-up $PGF_{2\alpha}$ injections.

Herds having heat detection programs that yield an average PR of 28% are estimated to obtain average days open almost identical to a SBP shown in Table 2 (122 days open and adjusted cost per pregnancy of \$88.30). The culling rate for a herd with a 28% average PR is estimated to be 2.8%. Therefore, it is not economically justified to use a SBP if the visual heat detection program produces an average PR of 28% or higher with labor costs of approximately \$10 per day with no additional expenses equal to hormonal treatment required for synchronization.

Factors to Consider in Selection of a Systematic Breeding Program

OvSynch®:

- Allows for fixed-time insemination in shortest period of time (9 days)
- No heat detection required
- Administered at a random stage of the estrous cycle
- Most labor and time efficient
- CR is usually lower than cows detected in "standing" heat
- Timing of all events is critical to success

PreSynch:

- Duration of initial hormone administration to timed AI (38 day) dictates use as 1st service protocol
- Slightly higher drug cost
- Optimizes CR if cows are cycling at time of $PGF_{2\alpha}$ injections

HeatSynch™:

- Requires limited amount (48 hours) of heat detection, thus SBP minimizes observation time or labor required for herds with high heat detection efficiency
- Lowest drug cost of three SBPs
- Estrus behavior and uterine tone may convey inseminator confidence
- Since this protocol includes two days of intense heat detection, may stimulate improved heat detection and insemination rates (and consequently PR) in cows returning to estrus in ~21 days
- Result similar to PreSynch SBP but may not be effective for synchronizing anovulatory cows

Conclusions

Basic research that identified the existence of follicular waves allowed for the development of protocols that synchronize both luteal regression and follicular maturation leading to ovulation. OvSynch® developed in the mid-90's allowed for the first SBP that obtained conception rates similar to those of cows artificially inseminated to detected estrus. Modifications of the OvSynch® SBP to maximize cows between day 5 and 12 in their estrous cycle (PreSynch) have shown a further enhancement in CR to timed AI. HeatSynch SBP is a less expensive alternative to PreSynch that includes 2 days of heat detection. HeatSynch™ SBP may not induce cyclicity in anovulatory cows as well as PreSynch. For best results, visual heat detection should be conducted between initial first cycle synchronization and resynchronization of cows not detected 18 to 24 days after the synchronized AI. Given that HeatSynch™ SBP includes 2 days of intense heat detection for each breeding cluster, this SBP may help to detect cows that return to estrus 18 to 24 days after the synchronized AI. Pregnancy diagnosis at 33 days allows for accurate determination without a high early post-pregnancy diagnosis early embryonic death loss experience with earlier ultrasonic imaging. It is not economically justified to use a SBP if the visual heat detection program produces an average PR of 28% or higher. All three SBP management strategies discussed reduce days open and increase average PR without a significant economic advantage of one SBP over the other.

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