EFFECTS OF RESYNCHRONIZATION ON FERTILITY & ECONOMICS

Todd R. Bilby[1], Ph.D.; Ricardo C. Chebel[2], D.V.M.; and Julio Giordano[3], Ph.D.
[1]Texas A&M AgriLife Research and Extension, Stephenville;
[2]Department of Veterinary Population Medicine, University of Minnesota, St. Paul;
[3]Department of Animal Science, Cornell University, Ithaca, NY
Email: trbilby@ag.tamu.edu

INTRODUCTION

Within the last decade, hormonal manipulation of the estrous cycle has been observed more frequently in dairy herds worldwide. Estrous synchronization programs have been researched extensively since the late 1990s (Pursley et al., 1995; Moreira et al., 2001; Dewey at al., 2010). The main objective of estrous resynchronization is to improve artificial insemination (**AI**) submission rates, decrease intervals between AI, reduce days open, and improve overall reproductive performance. Resynchronization programs have an advantage of allowing cows to be bred after completing the timed AI (**TAI**) protocol even though signs of estrus are not observed. However, many dairies utilize estrous detection within a TAI protocol in order to reduce costs and possibly improve fertility.

Until recently, research focused on evaluating fertility to TAI without considering the effects on estrous detection and overall fertility (i.e. both fertility of cows bred following detected estrus and TAI) to the entire reproductive program. This may lead to false conclusions and recommendations, since fertility may be drastically changed due to whether a dairy is utilizing estrous detection. In research studies in which cows are allowed to be inseminated when identified in estrus during the ovulation synchronization protocol, rarely was fertility of cows inseminated in estrus reported and included in the overall reproductive performance of the programs being tested. In addition, initiation of resynchronization programs occurs at or before non-pregnancy diagnosis, which can have implications on the number of cows detected in estrus depending on how early non-pregnancy diagnosis occurs. Of recent, activity monitors have grown in popularity as a tool to improve estrous detection and questions have been raised as to whether these are an additional tool or a replacement for synchronization programs.

Utilizing resynchronization programs continues to be an area of focus since fertility to resynchronization is normally lower than fertility at initial postpartum TAI. However, recent research has made improvements in fertility through additional hormone intervention by utilizing a common strategy used at first postpartum TAI called presynchronization. Understanding how the type of presynchronization strategy used before resynchronization, timing of non-pregnancy diagnosis, and distribution of estrus post-TAI will be important considerations for improved fertility to a resynchronization program. These considerations, along with an economic evaluation, will be discussed herein.

PRESYNCHRONIZATION PROGRAMS BEFORE RESYNCHRONIZATION

Resynchronization of non-pregnant cows continues to be a challenge for reproductive performance of dairy cows. According to published studies and on-farm data, pregnancy per AI (**P/AI**) of cows diagnosed

not pregnant and resynchronized with the Ovsynch protocol is usually < 30 %. The timing of initiation of ovulation synchronization protocols is fundamental, because it determines the likelihood of ovulation to the first GnRH injection, timing of luteolysis during the protocol, length of dominance of the ovulatory follicle, and ultimately synchrony of the estrous cycle. Vasconcelos et al. (1999) observed that when beginning the synchronization protocol between d 5 to 9 of the estrous cycle, significant improvement occurred for the percentage of cows that ovulate to the first GnRH (> 90 %) injection of an Ovsynch protocol. In addition, a new follicular wave is recruited within 40-48 h after the GnRH, a CL is present at the time of the prostaglandin (**PG**) $F_{2\alpha}$ injection (7 d later) resulting in synchronized luteolysis, and synchronized ovulation is induced with the second GnRH given on d 9.5 (Vasconcelos et al., 1999). Therefore, when implementing ovulation synchronization protocols, the estrous cycle should be presynchronized to assure that a large percentage of cows start such protocols between d 5 and 9 of the estrous cycle.

Therefore, it becomes evident that methods to presynchronize the resynchronization protocol have to be developed and implemented to increase P/AI of cows diagnosed not pregnant without offsetting any economic gain due to higher fertility with increased inter-AI breeding interval. Subsequently we discuss a few new methods of presynchronizing the resynchronization protocol.

RESYNCHRONIZATION PROTOCOLS EVALUATED WITHOUT ESTROUS DETECTION

Silva et al. (2007) evaluated a $PGF_{2\alpha}$-based presynchronization protocol before the start of the resynchronization. Therefore, cows were examined for pregnancy at 32 d after AI. Half of the cows diagnosed not pregnant were submitted to the Ovsynch protocol starting at 33 d after AI and were re-inseminated at 43 d after AI; whereas the other half of the cows were presynchronized with an injection of $PGF_{2\alpha}$ at 34 d after AI, were submitted to Ovsynch at 46 d after AI and were re-inseminated at 56 d after AI. The hypothesis was that by giving $PGF_{2\alpha}$ at 34 d after AI a large percentage of cows would start a new estrous cycle between 36 and 41 d after AI and consequently start the Ovsynch between d 5 and 10 of the estrous cycle. Pregnancy per AI was increased by presynchronizing cows with $PGF_{2\alpha}$ (35.2 vs. 25.6%). Interestingly, the percentage of cows that ovulated to the first GnRH injection of the Ovsynch was not different (53.9 vs. 49.3%) and; therefore, it was suggested that increases in P/AI may have been the result of improved uterine health because of the additional $PGF_{2\alpha}$ injection and the extra time between inseminations.

Giordano et al. (2012a) compared the reproductive performance of cows resynchronized with Ovsynch or Double-Ovsynch. Cows resynchronized with Ovsynch received the first GnRH at 32 d after AI and; if diagnosed not pregnant at 39 d after AI, they received $PGF_{2\alpha}$ at 39 d after AI, the second GnRH at 41 d, and TAI at 42 d. Cows resynchronized with Double-Ovsynch received GnRH at 22 d after AI, and if diagnosed not pregnant at 29 d after AI they received a $PGF_{2\alpha}$ at d 32, at d 39 a GnRH, at d 46 a $PGF_{2\alpha}$, at d 48 a GnRH, and at d 49 the TAI. Cows resynchronized with the Double-Ovsynch were more likely to ovulate to the first GnRH (85.4 vs. 68.9%) and had greater P/AI (38.5 vs. 30.0%).

A critical issue with both of these protocols is that the interval between AI was increased by 7 d in both protocols, despite the fact that cows in the Double-Ovsynch treatment (Giordano et al., 2012) were examined for pregnancy by ultrasound 10 d earlier. One possible alternative to reduce the interval between AI when presynchronizing with a $PGF_{2\alpha}$ injection is to inseminate cows that display estrus during the 12 d before the start of the Ovsynch protocol.

A good alternative to presynchronize the estrous cycle of cows of unknown pregnancy status is to treat them with GnRH. Considering that cows with follicles > 10 mm in diameter are likely to ovulate to a GnRH injection, it is expected that GnRH given at random stages of the estrous cycle would result in ovulation in > 40% of lactating dairy cows. Another alternative is to treat cows with a CIDR device during the resynchronization protocol, because treatment with a CIDR device during a TAI protocol results in improved synchronization of the estrous cycle. These alternatives were evaluated in a recent study conducted in AZ and CA (Dewey et al., 2010).

In this study, cows in the GGPG treatment were presynchronized with GnRH given 32 d after AI and, if diagnosed not pregnant on d 39 after AI, they were submitted to Cosynch72 (d 0 GnRH, d 7 $PGF_{2\alpha}$, and d 10 GnRH + TAI). Cows in the CIDR treatment group diagnosed not pregnant on d 39 after AI received Cosynch72 with the addition of a CIDR device between the GnRH and the $PGF_{2\alpha}$, given on d 0 and 7, respectively. The control treatment was the Cosynch72 protocol that started on d 39 after AI if cows were diagnosed not pregnant. The end result was greater P/AI for GGPG cows (31.2 %) than control cows (22.1 %). Further, cows

receiving a CIDR (29.5 %) had P/AI similar to that of cows in the GGPG group and greater than control cows. Presynchronizing cows with a GnRH 7 d before the start of the resynchronization and treating cows with a CIDR device during the resynchronization protocol increased P/AI by nearly 8 percentage points without extending the interval between AI.

An interesting finding of this study is the small percentage (~ 25 %) of cows that had luteolysis between the first GnRH injection (d 0) and the $PGF_{2\alpha}$ injection (d 7) of the Cosynch. The days when these injections were given would correspond, in cows with estrous cycle length of 22 d, to the beginning of proestrus of the estrous cycle immediately after AI and early metestrus of the second estrous cycle after AI, respectively. This demonstrates that a large percentage of cows do not have the expected 22 d interval to return to estrus after a previous AI.

RESYNCHRONIZATION PROTOCOLS EVALUATED WITH ESTROUS DETECTION

Although constantly new TAI protocols are developed and evaluated, the importance of inseminating cows based on signs of estrus continues to be significant. Many dairies today utilize estrous detection as part of their reproductive program. Recently our group has evaluated the effects on fertility of integrating different resynchronization protocols into a reproductive program that utilizes estrous detection.

The first study evaluated the effects of 2 resynchronization TAI protocols beginning at different intervals after AI on fertility in dairy cows (Bruno et al., 2011). Lactating cows from 2 dairies located in TX (n = 2233) and MN (n = 3077) were assigned to

1 of 4 TAI protocols 17 ± 3 d after AI. Cows assigned to Early Resynch or Resynch received the OvSynch56 starting 24 or 31 d after AI, respectively. Cows assigned to Early GGPG or GGPG received a presynchronizing GnRH 17 or 24 d after AI, respectively, 7 d before the start of OvSynch56. Any cow observed in estrus was AI on the same day. Fewer Early GGPG ($P < 0.01$) and more Resynch ($P < 0.01$) cows were re-inseminated in estrus (Early GGPG, 23.7 %; GGPG, 49.0 %; Early Resynch, 41.6 %; and Resynch, 57.6%). However, treatment did not affect ($P = 0.22$) P/AI 66 d after re-insemination (Early Resynch, 26.1 %; Early GGPG, 29.4 %; GGPG, 30.5 %; and Resynch, 30.4%). Cows re-inseminated in estrus, however, had greater P/AI at 66 d (36.0 vs. 23.9%) than cows that received TAI. We concluded that early start of resynchronization and presynchronization with GnRH reduced the number of cows re-inseminated in estrus and neither the timing nor the resynchronization protocol affected overall P/AI.

Since GnRH reduced the number of cows in estrus and increased the number of cows that entered the TAI program, which yielded a lower P/AI; then perhaps utilizing a $PGF_{2\alpha}$ injection for presynchronization with estrous detection will improve fertility. A second study was conducted to determine the speed at which cows not pregnant to a previous AI and that had their estrous cycle presynchronized with a GnRH or $PGF_{2\alpha}$ injection were re-inseminated and became pregnant (Chebel et al., 2012). Jersey (site A, MN) and Holstein (site B, WI) cows, 32 ± 4 d after AI, were assigned to 1of 2 presynchronization treatments: GGPG (n = 452) – GnRH injection at enrollment (d 0), 7 d before the start of the TAI protocol; and, P11GPG (n = 466) – $PGF_{2\alpha}$ injection on d 3, 11 d before the start of the TAI protocol.

Cows observed in estrus at any interval after enrollment were re-inseminated on the same day. Timed AI protocols were Ovsynch56 in site A and Cosynch48 in site B. Cows in herd A were examined by ultrasound 32 ± 4 d after AI and those diagnosed non-pregnant continued in the experiment (n = 611); whereas cows (n = 875) in herd B had blood samples collected on the day of enrollment (32 ± 4 d after AI) and analyzed for concentration of pregnancy specific protein-B (PSPB; Biopryn®, Biotracking, LLC, Moscow, ID). PSPB results were received 2.5 d after enrollment, thus cows in herd B enrolled in the GGPG treatment received the presynchronizing GnRH injection at enrollment without previous knowledge of pregnancy status. However, cows in herd B enrolled in the P11GPG treatment only received $PGF_{2\alpha}$ if diagnosed non-pregnant, 2.5 d after enrollment. Cows in the P11GPG treatment had faster re-insemination rates (Figure 1) and were less likely to be submitted to the TAI protocol (40.3 vs 89.8%) and to be re-inseminated at fixed time (38.6 vs 83.9%) as shown in Table 1. Consequently, the interval from enrollment to re-insemination was shorter for P11GPG cows than GGPG cows (Table 1 and Figure 1). Percentages of cows pregnant at 67 ± 4 d after re-insemination were not affected by resynchronization protocol; however, pregnancy rate from d 0 to 7 and from d 8 to 14 was greater for P11GPG cows (Table 1). The increased pregnancy rate illustrates the expedited re-insemination rate and establishment of pregnancy for cows injected with $PGF_{2\alpha}$. Authors concluded that fertility of non-pregnant cows that had their estrous cycles presynchronized with GnRH or $PGF_{2\alpha}$ was not different, but in herds with adequate estrous detection efficiency and accuracy, presynchronization with $PGF_{2\alpha}$ is likely to reduce the interval to establishment

Table 1. Effect of GGPG or P11GPG on pattern of re-insemination, pregnancy per AI (P/AI) after re-insemination, and pregnancy rates.

	GGPG	P11GPG	*P* – value
Insemination rate, AHR (95% CI)*	Referent	1.24	< 0.01
		(1.07, 1.45)	
Cows submitted to the TAI protocol, %	89.8	40.3	< 0.01
Cows inseminated at fixed time, %	83.9	38.6	< 0.01
Enrollment to re-insemination interval, days (±SEM)	15.0 ± 0.2	13.0 ± 0.4	< 0.01
P/AI 32 ± 4 d after re-insemination, %	42.3	39.3	0.43
P/AI 67 ± 4 d after re-insemination, %	37.0	35.4	0.70
Pregnancy loss from 32 to 67 ± 4 d after re-insemination, %	11.4	6.4	0.11
Pregnancy rate from 0 to 7 d after enrollment, %	3.6	17.7	< 0.01
Pregnancy rate from 8 to 14 d after enrollment, %	1.6	5.7	< 0.01

* AHR = Adjusted hazard ratio; 95% CI = 95% confidence interval

of pregnancy and to reduce the cost of resynchronization protocols.

It is important to note that, according to data from herd A, P/AI 32 ± 4 d after re-insemination tended to be (*P* = 0.10) affected by the interaction between presynchronization treatment and presence of CL on the day of enrollment. Cows in the GGPG treatment with a CL on the day of enrollment (CL+) had similar P/AI compared with P11GPG/CL+ cows (34.1 vs 32.7%, respectively). On the other hand, GGPG cows without a CL on the day of enrollment (CL-) had greater P/AI than P11GPG/CL- cows (44.4 vs 25%). This numerical difference was carried out to 67 ± 4 d after re-insemination (GGPG/CL+ = 30.8%, P11GPG/CL+ = 29.9%, GGPG/CL- = 37.7%, P11GPG/CL- = 22%), but there was no statistical significance (*P* = 0.22).
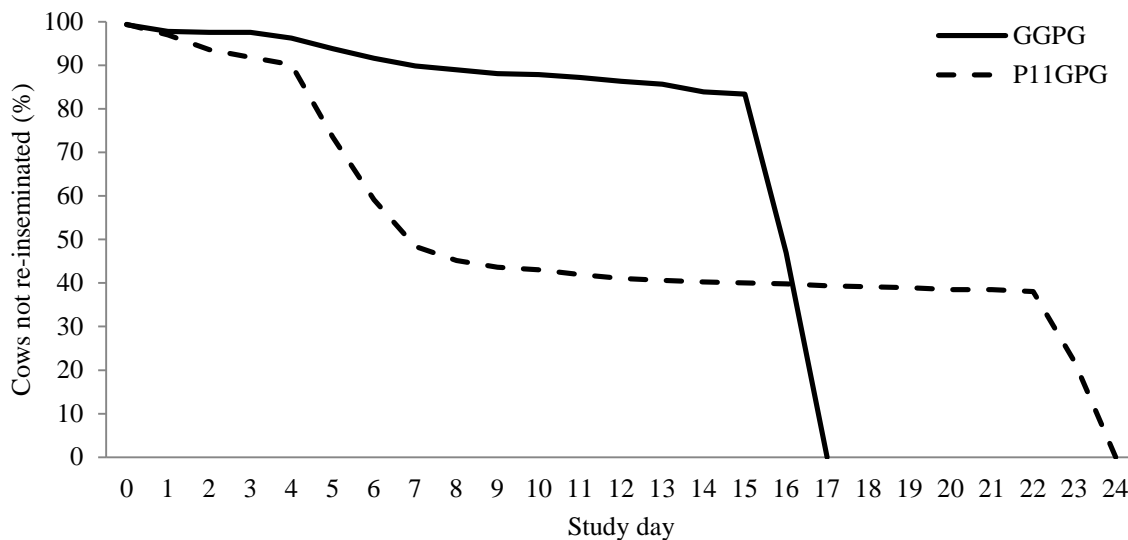

Figure 1. Survival analysis of interval from enrollment to re-insemination according to presynchronization treatment (Wilcoxon test of equality – *P* < 0.01).

This illustrates a possible advantage of ultrasound exam for diagnosis of non-pregnancy and ovarian structures, which would allow a more judicious decision regarding the resynchronization protocol for specific cows. Samples submitted for PSPB analysis, however, could also have been analyzed for progesterone (**P4**) concentration determining the best resynchronization protocol on presence (P4 ≥ 1 ng/mL) or absence (P4 < 1 ng/mL) of a viable CL. An obvious disadvantage of the PSPB test is the fact that results are not known until 48 to 72 h after sample collection, which may extend the interval between inseminations.

Lastly, an experiment was conducted to evaluate the use of $PGF_{2\alpha}$ at different intervals prior to resynchronization programs on fertility in lactating dairy cows (Bruno et al., 2012). Cows (n = 2,327) were assigned to 1 of 3 resynchronization protocols 7 d prior to non-pregnancy diagnosis (**NPD**) which is also experimental d 0:

- GGPG (n = 458), received GnRH at enrollment (d 0) and Ovsynch56 (GnRH 7 d later $PGF_{2\alpha}$, 56 h GnRH, and 16 h later TAI) at NPD 7 d later;
- P7GPG (n = 940) received a $PGF_{2\alpha}$ at NPD and Ovsynch56 7 d later; and
- P11GPG (n = 929) received a $PGF_{2\alpha}$ 3 d after NPD and Ovsynch56 11 d later.

The GGPG protocol reduced estrous detection and treatment did not affect overall P/AI at 66 d after AI or pregnancy loss

(Table 2). Cows AI upon estrous detection (**ED**) had greater P/AI then cows TAI (ED = 32.3, TAI = 25.1%). However, treatment did not affect P/AI for cows AI upon ED 66 d after AI or TAI (Table 2). Median days between NPD and AI was affected by treatment (GGPG = 10 vs. P7GPG = 4 and P11GPG = 7 d; Figure 2). This reinforces the fact that $PGF_{2\alpha}$ based programs increase ED and reduce the interval to first AI and between AI, while GnRH based programs increased the proportion of cows TAI. Also, cows AI upon ED had increased P/AI than cows TAI. Interestingly, shortening the interval from $PGF_{2\alpha}$ to the initiation of resynchronization did not negatively affect fertility at TAI and reduced interval to AI. However, caution should be taken when utilizing $PGF_{2\alpha}$ 7 d prior to resynchronization if estrous detection is NOT used as the majority of the cows would be at the incorrect stage of the estrous cycle when beginning resynchronization.

These studies illustrate how the number of cows detected in estrus is affected by timing of GnRH or PG injections and that caution should be exercised when recommending synchronization programs based on GnRH, particularly to herds with good AI submission rates and good P/AI to cows inseminated in estrus. Furthermore, if no benefits to overall reproductive performance are achieved by implementing protocols that reduce estrous expression, a significant increase in cost of reproductive programs will be observed because a greater percentage of cows have to be enrolled in fixed time AI protocols. Therefore, it may be advantageous for farms with acceptable

estrous detection and conception rates to utilize synchronization programs that are $PGF_{2\alpha}$ based (i.e. P7GPG, P11GPG) compared with GnRH based protocols (i.e. GGPG, G6G or Double-Ovsynch) due to the effects that these protocols have on reducing estrus. For example, in the study by Bruno et al. (2011, 2012) cows re-inseminated in estrus had P/AI 12 and 7 percentage units greater than cows that were re-inseminated at fixed time, respectively. Some of this reduction is possibly due to a less fertile population of cows entering the synchronization protocol due to the more fertile cows displaying estrus and being removed from the synchronization protocol.

Table 2. Effect of different presynchronization treatments and intervals on reproductive outcomes

Item, % (n/n)	GGPG	P7GPG	P11GPG	*P* - value
Enrollment, n	458	940	929	
Non-Pregnant 7 d after enrollment	42.0 (192/458)	40.6 (382/940)	37.5 (348/929)	
Estrus Detected (%, n/n)	21.9 (42/192)[b]	75.9 (290/382)[a]	78.2 (272/348)[a]	< 0.01
Timed AI (%, n/n)	78.1 (150/192)[a]	24.1 (92/382)[b]	21.8 (76/348)[b]	< 0.01
P/AI, 66 d (%, n/n)				
From 0 to 7 d	44.4 (8/18)	31.6 (24/79)	23.1 (14/65)	0.14
From 8 to 14 d	12.5 (3/24)[b]	26.7 (52/195)[a]	38.3 (57/149)[a]	< 0.01
From 15 to 21 d	25.7 (38/148)	40.0 (6/15)	37.5 (18/48)	0.19
From 22 to 28 d	-	20.1 (19/91)	22.2 (2/9)	0.36
From 29 to 35 d	-	-	18.4 (14/76)	-
Overall for Estrus Detected (%)	26.2 (11/42)[b]	28.4 (82/289)[a]	33.6 (91/271)[a]	0.31
Overall for TAI (%)	25.7 (38/148)	20.1 (19/91)	18.4 (14/76)	0.41
Overall (%)	25.7 (49/190)	26.6 (101/380)	30.3 (105/347)	0.38
Pregnancy loss (%, n/n)	7.1 (4/56)[*]	6.5 (7/108)	5.4 (6/111)	0.71
Pregnancy rate, 66 d (%, n/n)				
From 0 to 7 d	4.2 (8/190)[b]	6.3 (24/380)[a]	4.3 (14/347)[b]	< 0.01
From 8 to 14 d	1.7 (3/172)[b]	17.3 (52/301)[a]	20.2 (57/282)[a]	< 0.01
From 15 to 21 d	25.7 (38/148)[a]	5.6 (6/106)[c]	13.5 (18/133)[b]	< 0.01
From 22 to 28 d	-	20.9 (19/91)[a]	2.4 (2/85)[b]	< 0.01
From 29 to 35 d	-	-	18.4 (14/76)	-
Overall for Estrus Detected (%)	5.7 (11/190)[b]	21.6 (82/380)[a]	26.2 (91/347)[a]	< 0.01
Overall for TAI (%)	25.7 (38/147)	20.9 (19/91)	18.4 (14/76)	0.40
Overall (%)	25.7 (49/190)	26.6 (101/380)	30.3 (105/347)	0.38

[*] 3 cows from GGPG were culled before pregnancy reconfirmation at 66 days after AI.
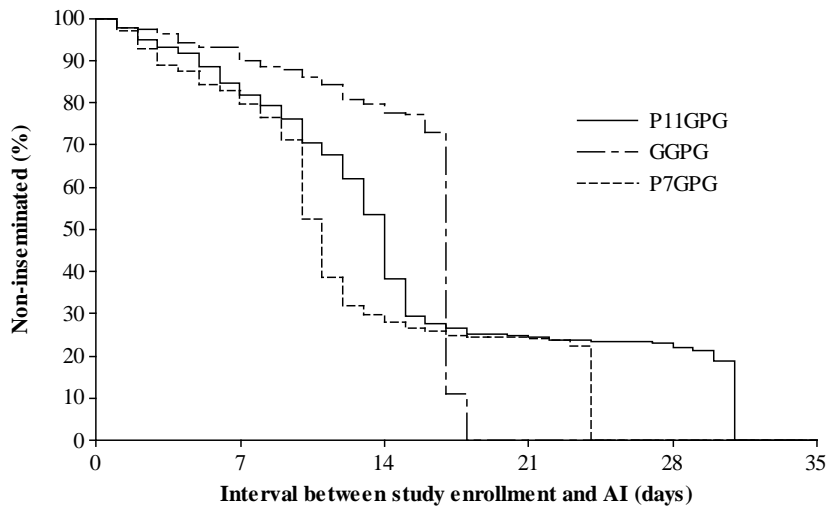[a,b,c] Within row, values with different superscripts differ (*P* < 0.05).

Figure 2. Kaplan-Mayer survival analysis illustrating the effect of resynchronization programs on interval between study enrollment and subsequent AI for 3 resynchronization programs.

TIMING OF PREGNANCY DIAGNOSIS WHEN INITIATING RESYNCHRONIZATION

Another consideration for when and what synchronization program to utilize is the timing of pregnancy diagnosis. Research continues to explore ways to reduce the interval between inseminations to increase the number of cows pregnant and reduce the number of days open. Several alternatives for pregnancy diagnosis are currently available, such as utilizing blood pregnancy tests as early as d 28 post-AI. Also, ultrasonography can be utilized at approximately 27 d post-AI and transrectal palpation is normally recommended at 32 d post-AI or greater, depending on technician skill level.

Most dairies initiate their resynchronization program either prior to or at non-pregnancy diagnosis. The time at which pregnancy diagnosis occurs and of subsequent initiation of the synchronization program may reduce expression of estrus depending on the timing and type of hormonal injection utilized as discussed previuosly. For example, in the (Bruno et al. 2011) study, if the first GnRH of GGPG began at 17 d after TAI instead of waiting until 24 d after TAI, estrous detection was reduced by 25 percentage units (24 vs. 49 %). Previous research has shown that > 50 % of the animals show estrus after d 21 with the greatest amount occurring before d 25 (Chebel et al., 2006). Also, if GnRH is utilized as a presynchronization tool instead of PG, number of cows detected in estrus can be reduced from 78 to 24 % after injection. Consequently, more cows would enter the synchronization program and receive TAI. This may reduce fertility and increase drug costs if the cows detected in estrus achieve conception rates similar to or greater than TAI. If synchronization protocols are implemented based on when non-pregnancy diagnosis occurs, caution should be given to the type of protocol utilized and timing of pregnancy diagnosis to maximize fertility and profitability.

ACTIVITY MONITORS AND RESYNCHRONIZATION

Recently studies were conducted to determine whether activity monitors could eliminate the need for TAI protocols completely. Two recent experiments, however, indicated that activity monitors are not able to achieve AI submission rates of > 85 % as some companies were claiming for the simple fact that some cows will not display estrus. Valenza et al. (2012) fitted 42 cows with an activity monitor system (collar) and a mounting detection system (Kamar® Heatmount® Detectors, Kamar Products, Inc., Zionsville, IN). The cows were synchronized and allowed to come in estrus. Cows were then examined by ultrasound to determine ovarian activity and occurrence of ovulation. In this small experiment, according to activity monitor and mounting detector 67 and 62 %, respectively, of cows were observed in estrus and ovulated; 7 and 12 %, respectively, of cows were not observed in estrus and ovulated; 5 % of cows were observed in estrus and did not ovulate; and, 21 % of cows were not observed in estrus and did not ovulate. Therefore, based on an activity monitor system and a mounting detection system 28 to 33 %, respectively, of cows were not observed in estrus. Furthermore, considering ovulation as the 'gold standard', cows that ovulated and were in estrus were +/+, cows that did not ovulate and were in estrus were -/+, cows that ovulated and were not in estrus were +/-, and cows that did not ovulate and were not in estrus were -/-. Thus, the activity monitor system and the estrous detection system resulted in sensitivity of 91 and 84 %, respectively, specificity of 81 %, positive predictive value of 93 %, and negative predictive value of 75 and 64 %, respectively. Therefore, based on this small experiment the activity monitor and mounting detection system had similar performance.

In a study presented at the 2012 American Dairy Science Association, researchers evaluated the insemination pattern and P/AI of cows that were fitted with activity monitors and were submitted to the Ovsynch protocol with ED, to the Presynch/Ovsynch with ED, and to the Presynch/Ovsynch protocol without ED (100 % TAI; Fricke et al., 2012). In this study, 70 % of cows that received 2 $PGF_{2\alpha}$ presynchronizing injections were observed in estrus; whereas approximately 57 % of cows that were not presynchronized with $PGF_{2\alpha}$ were observed in estrus. The P/AI of cows inseminated in estrus was 30 % and the P/AI of cows inseminated at fixed time was 36 %. These numbers are very similar to those reported by Chebel et al. (2006, 2010b) and Lima et al. (2009). In these studies the percentage of cows that were inseminated in estrus after 2 presynchronizing injections of $PGF_{2\alpha}$ ranged from 50 to 62 %. On the other hand, P/AI of cows inseminated in estrus ranged from 27 to 44 % and P/AI of cows inseminated at fixed time ranged from 21 to 41%. The results from these studies suggest that activity monitors may perform just as well as detection of estrus based on tail paint removal and that P/AI of cows inseminated in estrus based on activity or tail paint removal may be similar, these being extremely dependent on farm and personnel.

Field observations of 2 herds that adopted the activity monitor systems for estrous detection and abolished the use of fixed TAI for first postpartum AI demonstrate that there is a significant risk of increasing significantly the variability in interval to first AI, increasing interval to first postpartum AI, and reducing AI submission rate and pregnancy rate.

Although this was not data from controlled studies, it was possible to observe that once TAI protocols stopped being used in the herds that adopted the activity monitoring system their pattern of first postpartum AI started to resemble the pattern of first postpartum AI before TAI protocols were widely adopted.

ECONOMICS OF RESYNCHRONIZATION PROGRAMS

Understanding the economic benefits/pitfalls to making a change to a reproductive program is important for making an informed decision. An economic analysis was performed as a continuum to the above described study by Dewey et al. (2010) in order to evaluate the pattern of re-insemination, pregnancy outcomes to re-insemination in estrus and at fixed time, and economic outcomes of lactating Holstein cows submitted to the Cosynch72, GGPG or CIDR resynchronization protocols (Mendonca et al., 2012). However, the economic analysis was performed only utilizing data from the CA site and incorporating cows that were re-inseminated upon estrus. In brief, costs of the resynchronization protocols were calculated for individual cows and pregnancies generated were given a value of $ 275. The GGPG treatment resulted in the slowest ($P \leq 0.06$) rate of re-insemination. Although cost of the control ($3.80) protocol was ($P < 0.01$) the smallest compared to the GGPG ($9.70) and CIDR ($10.60) protocols, return per cow resynchronized was ($P < 0.01$) greater for GGPG ($77.60) and CIDR ($73.00) protocols compared to control ($72.90). We concluded that presynchronizing cows with a GnRH injection alters significantly the pattern of re-insemination, reducing the re-insemination rate and increasing the interval between inseminations. Although the cost of

the GGPG and CIDR resynchronization protocols was higher than the control protocol, because GGPG and CIDR protocols resulted in numerically larger numbers of pregnant cows, and consequently greater pregnancy added value after re-insemination (Control, $82.60; GGPG, $92.40; and CIDR, $78.20) the return per resynchronized cow was greater for GGPG and CIDR treatments.

Even though the information obtained from applying economic analyses to resynchronization experiments may help producers and consultants in making an informed decision at the time of selecting a reproductive management program, dairy producers continually seek easy-to-use on-farm decision making tools capable of assessing their own farm rather than general results from the literature or field data from other farms. Another advantage of using simulation tools is that the whole herd dynamics can be simulated, thus the actual impact of reproduction programs on cost (added labor, hormones, AI, and pregnancy diagnosis) and benefits (potentially increased milk production, more calves born, and reduced culling) can be evaluated rather than assigning preset values to costs and even more important to days open or a pregnancy. In this regard, several University research groups have developed decision support tools to evaluate the economic impact of using different reproductive management programs in dairy herds using data from the farm under consideration (Groenendaal et al., 2004; DeVries et al., 2004; Giordano et al., 2011; 2012b). Using one of the tools developed at the University of Wisconsin and Cornell University (Giordano et al., 2012b) we performed an economic evaluation to compare the potential impact on profitability of the 3 resynchronization protocols (GGPG, P7GPG, and P11GPG) tested in Bruno et al. (2012)

and Chebel et al. (2012) for a large dairy herd in the US.

Our main objective was to determine which of the 3 resynchronization strategies would be the most economically beneficial to a dairy farm under the conditions stipulated in this simulation study. A hypothetical 2,000-cow dairy herd with a rolling herd average (**RHA**) of 27,000 lb of milk/cow was simulated. Economic parameters included a milk price of $18.00/cwt, $0.13 lb/DM of feed for lactating and $0.06 lb/DM of feed for dry cows, $1,250 for a heifer replacement, $0.60/lb for cull cows, and $150 and $50 for a female and male calf, respectively. Input values used by the tool to calculate the cost of performing each of the reproductive management programs included: $2.00/dose for GnRH, $1.80/dose for PGF, $10.00/AI (including semen and labor), $10.00/h for estrous detection performed 4 h/d, $0.33/injection to administer hormones for synchronization, and $2.50/cow for veterinary services to determine pregnancy status. To better evaluate the impact of the resynchronization strategy, the same program for first service postpartum AI was used for the 3 scenarios compared. This program consisted of Presynch-Ovsynch-11 with AI after detection of estrus (cherry picking) from the second PGF of Presynch given at 50 DIM (**VWP**) until the beginning of the Ovsynch protocol for synchronization of ovulation and TAI. The percentage of cows detected in estrus was set at 50 % with resulting P/AI of 38 %, reflecting the typical performance observed in western US dairy herds. In addition, from first AI until the time of enrollment in the resynchronization protocols (36 d for P7GPG and P11GPG and 29 d for GGPG) 60 and 50 % (reduced to reflect the observed reduction in expression of estrus after a GnRH injection) of the cows for the PGF based and the GnRH based

program, respectively, were detected in estrus and inseminated. Pregnancies per AI for cows detected in estrus was set at 34 %.

As expected due to the observed reproductive performance, the P7GPG program was the most profitable outperforming the GGPG program by $4.10/cow/yr and the P11GPG program by $4.30/cow/yr; whereas GGPG and P11GPG had almost similar economic value. These economic results for P7GPG and P11GPG likely reflect the balance between the improvement in performance by inseminating cows after detection of estrus and the extended interval until TAI for cows not detected in estrus. While more cows were detected in estrus and AI after the PGF injection at enrollment, the remaining cows had an extended period of time until they reached TAI. These seemed especially important for P11GPG which had the lowest economic value. With the GGPG program fewer cows were detected in estrus and inseminated, but the interval until TAI was 7 and 11 d shorter than for cows receiving TAI in P7GPG and P11GPG, respectively. Nevertheless, the lack of improvement on P/AI for cows reaching the TAI in GGPG precluded any major economic benefit with this protocol. These observations reinforce the idea that if cows are enrolled in resynchronization protocols that reduce expression of estrus it is imperative to increase the fertility of TAI services to avoid negative consequences on overall returns.

Even though any improvement on profitability would be of value to a dairy farm, it is worth noting that the relatively small economic differences (~$4.00/cow/yr) resulting from the scenarios compared are likely explained by the fact that the same program and performance was stipulated for first service AI and the time period from each AI until the time of enrollment to the

resynchronization treatments. Removing 50 to 60 % of the cows AI in estrus with resulting similar P/AI reduces the impact of the resynchronization protocol used for cows non-detected in estrus. Obviously, not inseminating cows in estrus and allowing all cows to reach TAI would dramatically impact the economic value of the programs. The overall P/AI for TAI in all 3 programs should increase significantly to offset the negative impact of not inseminating cows in estrus and having an extended interval between inseminations. Such improvement in P/AI should be even greater for the P7GPG and P11GPG protocols because their use results in longer intervals between TAI services than for the GGPG protocol. This notion has been confirmed by other resynchronization simulation studies (Giordano et al., 2011) which have demonstrated that increasing the interbreeding interval by 7 d when using 100 % TAI programs for second and subsequent services requires major gains in fertility (from 30 to 39 %) to offset a greater interbreeding interval.

In summary, the economic value of a resynchronization program will depend on the balance between the timing and the proportion of cows re-inseminated after detection of estrus and cows receiving TAI as well as the fertility of both types of AI services. Implementing programs that reduce expression of estrus, forcing more cows to reach TAI without improving the fertility of TAI services, will likely result in economic losses to a dairy farm; whereas programs that rely on estrous detection for extensive periods of time (> 7 d) may also be detrimental by increasing dramatically the interval between TAI services. Although the results of simulation studies using decision-support tools are useful to better understand the economic impact of using different reproductive management

programs, the outcome of such evaluations depends completely on the input values used. Therefore, it is advisable that dairy farmers and consultants interested in evaluating the potential impact of changing a reproductive management program evaluate the consequences of such changes using data for the farm under consideration.

CONCLUSIONS

Strides continue to be made in improving fertility to resynchronization programs. Using presynchronization protocols before the start of a resynchronization program improves fertility compared with cows initiating the resynchronization program at random stages of their estrous cycle. Presynchronization with a GnRH injection will reduce the number of cows displaying estrus and increase the number of cows which receive TAI. However, the opposite will occur when utilizing a PG injection, which is an important consideration if a dairy farm is utilizing estrous detection. Timing of GnRH injections prior to resynchronization can greatly reduce number of cows detected in estrus if given before d 25. Activity monitors are an additional tool which can aid in improving estrous detection; however, they do not observe 100 % of the cows in estrus so a robust resynchronization program is still important to use as an insurance tool to insure that all cows receive TAI by a certain DIM. Economics of resynchronization can be greatly influenced by the proportion of cows detected in estrus, inter-AI breeding interval, and P/AI of both cows TAI and detected in estrus, which are often not considered in research studies that are designed to only improve TAI fertility. Future studies should continue to focus on improving TAI fertility without negatively affecting the number of cows displaying estrus.

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