Inseminations at Estrus Induced by Presynchronization Before Application of Synchronized Estrus and Ovulation*

J. S. Stevenson¹ and A. P. Phatak²

¹Department of Animal Sciences and Industry,
Kansas State University, Manhattan 66506-0201

²Foster Dairy Farms, Hickman, CA, 95323

ABSTRACT

A controlled field study examined conception rates after 2 timed artificial insemination (TAI) breeding protocols conducted on 2 commercial dairy farms. Estrous cycles in postpartum lactating cows were presynchronized with 2 injections of PGF_{2α} given 14 d apart (Presynch) and then, after 12 d, the standard Ovsynch protocol (injection of GnRH 7 d before and 48 h after an injection of PGF_{2α}, with one TAI at 12 to 16 h after the second GnRH injection) or Heatsynch protocol [injection of GnRH 7 d before an injection of PGF_{2α}, followed 24 h later by 1 mg of estradiol cypionate (ECP) and one TAI 48 h after ECP] was applied. Experimental design allowed artificial insemination to occur anytime after the second Presynch injection and during the designed breeding week when estrus was detected. Of the 1846 first services performed, only 1503 (rate of compliance = 81.4%) were performed according to protocol. Numbers of cows inseminated, logistic-regression adjusted conception rates, and days in milk (DIM) were for inseminations made: 1) during 14 d after first Presynch injection (n = 145; 22.6%; 54 ± 0.4 DIM); 2) during 12 d after second Presynch injection (n = 727; 33%; 59 ± 0.2 DIM); 3) during 7 d after the first GnRH injection of Ovsynch or Heatsynch (n = 96; 32.1%; 74 ± 0.5 DIM); 4) after estrus as part of Heatsynch (n = 212; 44.6%; 76 ± 0.3 DIM); 4) after TAI as part of Heatsynch (n = 154; 21.1%; 76 ± 0.4 DIM); 5) after estrus as part of Ovsynch (n = 43; 48.7%; 77 ± 0.7 DIM); and 6) after TAI as part of Ovsynch (n = 271; 24.4%; 77 ± 0.3 DIM). Conception rates when AI occurred after one Presynch injection were less than when AI occurred after 2 Presynch injections. Conception rates for those inseminated after either Presynch injection did not differ from those inseminated after combined Heatsynch + Ovsynch. Cows in the Ovsynch and Heatsynch protocols inseminated

after estrus during the breeding week had greater conception rates than those receiving the TAI, but overall conception rates did not differ between protocols. Among cows inseminated after detected estrus, conception was greater for cows in the Heatsynch + Ovsynch protocol (77 ± 0.4 DIM) than for those inseminated after either Presynch injection (54 ± 0.4 or 59 ± 0.2 DIM). We concluded that conception rates after Heatsynch and Ovsynch were similar under these experimental conditions, and that delaying first AI improved fertility for cows inseminated after detected estrus.

(**Key words:** calving difficulty, compliance, conception, synchronized estrus)

Abbreviation key: CDS = calving difficulty score, ECP = estradiol cypionate, Heatsynch = injection of GnRH 7 d before an injection of PGF_{2α}, followed 24 h later by 1 mg of ECP and one fixed-time AI 48 h after ECP, Ovsynch = injection of GnRH 7 d before and 48 h after an injection of PGF_{2α}, with one timed AI at 12 to 16 h after the second GnRH injection, TAI = timed AI, VWP = voluntary waiting period.

INTRODUCTION

Various programmed-breeding protocols have been developed to synchronize estrus and ovulation in lactating dairy cows to initiate first services. These include the standard **Ovsynch** protocol (Pursley et al., 1997a) and variations that may include estrogen administration to induce estrus during the breeding week (**Heatsynch**; Pancarci et al., 2002). Recently, the only estrogen product in the United States (estradiol cypionate; **ECP**) was removed from the market. In general, conception or pregnancy rates after either of these 2 protocols are similar (Pancarci et al., 2002; Stevenson and Tifany, 2004). When estrous cycles are presynchronized (Moreira et al., 2001; El-Zarkouny et al., 2004) or staged according to days of the estrous cycle (Vasconcelos et al., 1999) so that a majority of cows are in mid-diestrus (d 5 to 12) at the onset of the Ovsynch protocol, resulting pregnancy rates are enhanced, compared with those of cows beginning the Ovsynch protocol at random stages of the estrous cycle.

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Corresponding author: J. S. Stevenson; e-mail: jss@ksu.edu.

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The question often asked is whether it is advisable to inseminate cows earlier during the administration of these protocols when estrus is detected after either of the Presynch injections of PGF_{2α} and the cow is at or near the end of the voluntary waiting period (VWP). Conception rates for cows inseminated after estrus tend to be greater (Stevenson et al., 1996; 1999; DeJarnette et al., 2001) or similar to those of cows receiving timed AI (TAI; Pursley et al., 1997b) to which are applied various Ovsynch-like protocols.

A related question is what is the ideal VWP to be applied on individual dairy farms or in the industry today, when most cows are inseminated after some controlled breeding program. Earlier studies (before application of controlled-breeding programs) in which cows were submitted for AI at predetermined DIM generally reported a significant or numerical trend for increased conception after a longer VWP (Whitmore et al., 1974; Britt, 1977; Stevenson et al., 1983). A recent study was conducted in which low- and high-producing dairy cows were inseminated at different DIM as part of the Ovsynch protocol (Tenhagen et al., 2003). In both milk-production groups, conception rates were improved by delaying first services 3 wk from 53 to 59 (14.4%) to 73 to 81 DIM (34.5%) for low-producing cows and from 73 to 81 (28.2%) to 94 to 102 DIM (41.4%) for high-producing cows, respectively.

The objective of our study was to determine pregnancy outcomes of 2 standard breeding protocols (Ovsynch and Heatsynch) in which estrous cycles were presynchronized with 2 injections of PGF_{2α} (Presynch) and inseminations occurred whenever estrus was detected anytime after the second Presynch PGF_{2α} injection. Ancillary objectives were to determine compliance to the designed protocols and whether DIM was a significant factor in accounting for different conception rates.

MATERIALS AND METHODS

Management of Cows

A controlled study was conducted at 2 (dairy #3 and dairy #5) of 5 Foster Dairy Farms, Hickman, CA. Lactating Holstein cows ($n = 1846$) that calved between February 2, 2001, and February 1, 2002, were included in the study, consisting of first postpartum inseminations conducted between March 22, 2001 and April 28, 2002. All 5 Foster Dairy Farm herds were managed similarly by one central management team, having different herdsmen and inseminators at each dairy. All cows at each dairy were fed a TMR to meet or exceed requirements recommended for lactating dairy cows (NRC, 1989). Diets were mixed from common ingredients located at dairy #2 to feed cows at dairy #2 and #3 or at dairy #5 to feed cows at dairy #4, #5, and #6.

Diets consisted of alfalfa, soybean meal, bypass soya, corn silage, barley, flaked corn, brewer's grains, beet pulp, and added minerals. Cows were milked and fed three times daily so fresh feed was available when cows returned to pens from the milking parlor after each milking (0400, 1200, and 2000 h). No recombinant bST was used in these herds.

Experimental Design

The study was designed to compare conception rates of lactating dairy cows inseminated at first service in response to 2 estrus- and ovulation-synchronization protocols [Ovsynch (injections of GnRH 7 d before and 48 h after PGF_{2α}) and Heatsynch (injection of GnRH 7 d before and an injection of ECP 24 h after PGF_{2α})]. Before applying each protocol, estrous cycles of cows were presynchronized by using 2 injections of PGF_{2α} (13 to 15 d apart; Presynch), with the second Presynch injection occurring 11 to 12 d before initiating either of the 2 protocols. Cows were assigned to begin the Presynch injection sequence based on calving dates, grouped into breeding clusters every 10 d, beginning no sooner than 40 DIM. Doses and sources of hormones were: PGF_{2α} (25 mg; Lutalyse, Pharmacia Animal Health, Kalamazoo, MI); estradiol cypionate (1 mg; ECP; Pharmacia Animal Health), and GnRH (100 μg; Cystorelin, Merial Ltd., Iselin, NJ). All hormones were administered i.m. into the gluteal muscles.

Experimental protocols were designed for insemination of cows after detected estrus that occurred: 1) during 12 d after the second of 2 Presynch injections; 2) during 7 d after the first GnRH injection of Ovsynch or Heatsynch (some received PGF_{2α} 7 d later and were inseminated that day); or 3) during the breeding week when the ECP injection of Heatsynch or the second GnRH injection of Ovsynch was administered. Therefore, any cow that was detected in estrus 24 or more hours after the PGF_{2α} injection of the Ovsynch or Heatsynch protocol was eligible for insemination by design. In the absence of previous AI, cows in the Ovsynch protocol were inseminated at 12 to 16 h after the second GnRH injection and those in the Heatsynch protocol were inseminated at 48 h after ECP.

All hormonal injections and their dates of administration, calving difficulty scores (CDS), calving and breeding dates, AI at estrus or TAI, pregnancy outcomes, etc., were recorded in DHI records (DHI-Provo). As a result, actual dates of hormonal injections and inseminations could be verified to determine protocol compliance. Of the 1846 inseminations recorded during the experimental period, some cows were inseminated contrary to study design.

Four individuals conducted all inseminations at dairy #3 and 4 different individuals conducted inseminations at dairy #5. The same AI sires were used at both dairies. Therefore, effects of inseminator were confounded with herd. Inseminations associated with estrus were conducted between 8 and 16 h after detected estrus (a.m. - p.m. rule). Detected estrus was defined to include: 1) visually detected standing to be mounted, 2) tail-chalk rubs, and 3) other secondary signs (mucus or ruffled tail-head hair). Where chalk rubs or secondary signs were detected, cows were often palpated to detect uterine tone for validation of potential accuracy of the suspected estrus. These determinations of defined estrus were judgments made by the inseminators.

Cows were locked up at the feed bunk each morning between 0800 and 1000 h to conduct hormonal injections, read and apply new tail chalk, diagnose pregnancy, and perform other health treatments. When cows were detected in standing estrus after morning chalk reads, they were inseminated that evening.

Conception rates (no. of pregnancies ÷ no. of cows inseminated) were calculated from pregnancy diagnoses that were conducted weekly by palpation per rectum of the uterus and its contents at a minimum of 35 to 41 d since last AI.

Statistical Analyses

For statistical comparisons, 5 AI breeding scenarios were summarized in which insemination occurred: 1) during 14 d after a single injection of PGF_{2α} (1×PGF; n = 145); 2) during 12 d after the second of 2 injections of PGF_{2α} given 14 d apart (2×PGF; n = 727); 3) during 7 d after the first GnRH injection of Ovsynch or Heatsynch (2×PGF + GnRH ± PGF; n = 96); 4) after the PGF_{2α} injection of the Heatsynch protocol (n = 366); or 5) after the PGF_{2α} injection of the Ovsynch protocol (n = 314). For the Heatsynch and Ovsynch protocols, 2 subgroups in each protocol were formed, in which cows were inseminated based on detected estrus [Heatsynch (n = 212) vs. Ovsynch (n = 43)] or, in the absence of estrus, received a TAI as defined [Heatsynch (n = 154) vs. Ovsynch (n = 271)].

Conception rates were analyzed using logistic regression (procedure GENMOD; SAS Inst., Inc., Cary, NC). Independent variables in the model were: treatment (1×PGF, 2×PGF, 2 ×?PGF + GnRH ± PGF, Heatsynch estrus, Heatsynch TAI, Ovsynch estrus, and Ovsynch TAI), lactation number (1, 2, and 3+), season (n = 2), and herd (n = 2), plus interactions of treatment and lactation number. Covariables included in the model were CDS (1 = no assistance; 2 = slight problem; 3 = need assistance; 4 = considerable force; and 5 = extreme force), and DIM at time of AI. A similar model was used

in which CDS was a fixed effect (1 + 2 vs. 3 + 4 + 5). A similar model was used to examine the proportion of cows inseminated after estrus in the Heatsynch and Ovsynch protocols. Because DIM at insemination accounted for a significant amount of the variation in pregnancy outcomes, DIM at insemination was analyzed by ANOVA (GLM in SAS) with the independent variables: treatment, lactation number, their interaction, herd, and season, with CDS as a covariable.

Least square mean percentages for conception rate were separated by constructing 6 orthogonal contrasts in procedure GENMOD: 1) 1×PGF vs. 2×PGF (confounded effect of DIM and treatment); 2) 2×PGF vs. 2×PGF + GnRH ± PGF (confounded effect of DIM and treatment); 3) 1×PGF + 2×PGF + 2×PGF + GnRH ± PGF vs. Heatsynch + Ovsynch [confounded effect of DIM and treatment (estrus vs. TAI)]; 4) Heatsynch vs. Ovsynch (differences in treatment protocols that reflected more cows inseminated after estrus in Heatsynch than Ovsynch); 5) TAI (Heatsynch + Ovsynch) vs. estrus (Heatsynch + Ovsynch); and 6) 1×PGF + 2×PGF vs. Heatsynch + Ovsynch (differences in conception rate after estrus on the basis of DIM resulting from delayed insemination).

RESULTS AND DISCUSSION

Compliance to Protocol

Of the 1846 first services performed, only 1503 (81.4%) were performed according to the designed protocol. These breaches in protocol included missed or mistimed injections, hormonal injection sequence errors, and in some instances, cows receiving both ECP and GnRH during the breeding week. Our protocol dictated that cows were eligible to be inseminated anytime once estrus was detected after the second Presynch injection until the scheduled TAI associated with the Heatsynch or Ovsynch protocols. Noncompliant inseminations included those conducted during 14 d after the first Presynch injection (n = 145; 7.9%) and those (n = 198; 10.7%) that did not comply with the protocol. Of the 2 deviations from protocol, the latter was most serious because pregnancy outcomes were most compromised as measured by actual conceptions rates (22.2%), which included inseminations after detected estrus (conception rate = 26%; n = 130) and TAI (conception rate = 15%; n = 68).

Proportions of Estrus and DIM

Inseminations made after the first Presynch injection were included in statistical analyses so conception rates after fewer DIM could be examined. Of 1648 inseminations performed after the 5 breeding scenarios, 968

(58.7%) occurred after either 1 (1×PGF) or 2 (2×PGF) injections of PGF_{2α}, or during 7 d after the beginning GnRH injection of Heatsynch or Ovsynch. More ($P = 0.01$) cows in the Heatsynch protocol were inseminated during the designed breeding week after or in association with expressed estrus (57.9%) than in the Ovsynch protocol (13.6%). These differences between Ovsynch and Heatsynch were consistent across lactation numbers, but more first- and second-lactation cows than older cows were detected in estrus after Heatsynch compared with those after Ovsynch (treatment × lactation number interaction; $P < 0.01$; first lactation: 63.6 vs. 17.8%; second lactation: 67.8 vs. 9.8%; and third or greater lactation: 47.8 vs. 13.6%).

Days in milk at each insemination based on the 7 statistically compared protocols are summarized in Table 1. Cows in 1×PGF were inseminated 5 ± 0.2 d earlier ($P < 0.01$) than cows in 2×PGF, whereas both groups were inseminated 15 to 20 d earlier ($P < 0.01$) than cows inseminated during 7 d after the beginning GnRH injection of Heatsynch or Ovsynch, and 17 to 23 d earlier ($P < 0.01$) than those that completed the designed Heatsynch and Ovsynch protocols.

Pregnancy Outcomes

Unadjusted and logistic-regression adjusted mean conception rates are summarized in Table 1 for the 5 breeding scenarios, as are orthogonal contrasts of adjusted means. Although significant differences were detected for 3 of 6 contrasts, some contrasts included confounding treatment protocols with DIM. The first contrast indicated that the adjusted conception rates increased ($P < 0.05$) from 22.6 to 33% because of the additional injection of PGF_{2α}, but DIM at AI also increased ($P < 0.01$) from 54 to 59 (Table 1). Therefore, it is not clear whether difference in conception occurred because of the additional PGF_{2α} injection or because DIM was longer at AI.

The second contrast compared cows receiving both Presynch injections with those inseminated during 7 d after receiving the beginning GnRH injection of the Heatsynch or Ovsynch protocol. The latter scenario included some cows that received the PGF_{2α} injection for those 2 protocols, but were inseminated on that day before receiving subsequent injections associated with Heatsynch (i.e., ECP) or Ovsynch (i.e., GnRH). These cows were likely coming into estrus spontaneously despite the injection of PGF_{2α}. Although DIM was longer ($P < 0.01$) for cows in the latter protocol, conception rates (33 vs. 32.1%) did not differ from the 2×PGF cows (Table 1). Again, this contrast confounds treatment (2 PGF_{2α} injections vs. 2 or 3 PGF_{2α} injections + GnRH) with DIM.

The third contrast also confounds DIM with treatment protocol (detected estrus vs. detected estrus + TAI). Although all cows were inseminated after detected estrus in 1×PGF, 2×PGF, and 2×PGF + GnRH ± PGF groups, only 37.5% of the cows in Heatsynch + Ovsynch were inseminated after or in association with expressed estrus. Conception rates (28.3 vs. 31.5%) did not differ between groups (Table 1).

The fourth contrast (TAI: Heatsynch + Ovsynch vs. estrus: Heatsynch + Ovsynch) compared conception rates of cows inseminated after TAI vs. after detected estrus. Cows inseminated after expressed estrus had greater ($P < 0.001$) conception rates (45.3 vs. 23.2%) than those receiving the TAI at similar DIM (Table 1), when treated with either the Heatsynch or Ovsynch protocol.

The fifth contrast was a comparison of the overall outcomes from the Heatsynch vs. Ovsynch protocols (Table 1). Pregnancy outcomes did not differ between the 2 protocols. Conception rates of cows inseminated after Heatsynch and Ovsynch, when estrus occurred, were nearly identical as were those for cows receiving the TAI regardless of protocol (Table 1). Overall numerical differences between Heatsynch (34.7%) and Ovsynch (27.7%) are explained by proportionally more cows having greater conception rates after inseminations associated with expressed estrus (Heatsynch vs. Ovsynch: 57.9 vs. 13.6%) compared with fewer cows having lower conception rates after receiving the TAI.

The sixth contrast compared conception rates of cows after detected estrus at different DIM (estrus: 1×PGF + 2×PGF vs. estrus: Heatsynch + Ovsynch). This contrast verified that conception rates were increased ($P < 0.01$) in cows when inseminations, based solely on estrus, occurred after more DIM (31.3 vs. 45.3%; Table 1).

One might argue that the additional hormonal treatments [GnRH, PGF_{2α}, and ECP (Heatsynch cows only)] applied to cows in the Heatsynch and Ovsynch protocols could account for observed differences. This was not true, however, in a recent study in which low- and high-producing dairy cows were inseminated after an Ovsynch protocol applied at different DIM (Tenhagen et al., 2003). In both milk-production groups, conception rates were improved by delaying first services 3 wk from 53 to 59 DIM to 73 to 81 DIM for low milk-producing cows and from 73 to 81 DIM to 94 to 102 for high milk-producing cows.

A large percentage of the cows calved unassisted (CDS = 1: 1282 of 1846 or 69.4%). Numbers of cows with scores of 2 (14%), 3 (14.8%), 4 (2%), and 5 (0.3%) made up the remainder. Greater CDS was associated negatively with subsequent conception rate. For every 1-unit (range of 1 to 5) increase in calving difficulty, conception rate was reduced ($P < 0.01$) by $4.8 \pm 1.4\%$.

Table 1. Conception rates at first services in lactating dairy cows after various protocols.

Item	Protocol ¹						
	1×PGF	2×PGF	2×PGF + GnRH ± PGF	Heatsynch (HS)		Ovsynch (OVS)	
				Estrus	TAI	Estrus	TAI
No. of cows	145	727	96	212	154	43	271
Average DIM at AI	54 ± 0.4 ^a (40 to 89)	59 ± 0.2 ^b (51 to 102)	74 ± 0.5 ^c (65 to 95)	76 ± 0.3 ^d (71 to 118)	76 ± 0.4 ^d (73 to 106)	77 ± 0.7 ^d (73 to 84)	77 ± 0.3 ^d (73 to 110)
Pregnancy rate ² , %							
Unadjusted	22.8	32.6	33.3	45.3	22.7	51.2	25.5
Adjusted	22.6	33.0	32.1	44.6	21.1	48.7	24.4
Orthogonal contrasts:							
1×PGF vs. 2×PGF	22.6* (145)	33.0 (727)					
2×PGF vs. 2×PGF + GnRH ± PGF		33.0 (727)	32.1 (96)				
1×PGF + 2×PGF + 2×PGF + GnRH ± PGF vs. HS + OVS		28.3 (968)			31.5 (680)		
TAI (HS + OVS) vs. estrus (HS + OVS)				23.2*** (425)		45.3 (255)	
Heatsynch vs. Ovsynch				34.7 (366)		27.7 (314)	
Estrus only: 1×PGF + 2×PGF vs. HS + OVS		31.3** (872)			45.3 (255)		

^{a,b,c,d}Means with different superscript letters differ ($P < 0.01$).

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$.

¹Cows were inseminated after a single injection of PGF_{2α} (1×PGF); after the second of 2 injections of PGF_{2α} given 14 d apart (2×PGF); after the first GnRH injection of Ovsynch or Heatsynch (some received PGF 7 d later and were inseminated that day; 2×PGF + GnRH ± PGF); after estrus induced by estradiol cypionate (ECP) injection of Heatsynch (GnRH injection 7 d before PGF_{2α} and ECP given 24 h after PGF_{2α}); timed AI at 48 h after the PGF_{2α} injection of Heatsynch; after estrus following the PGF_{2α} injection of Ovsynch (injection of GnRH 7 d before and 48 h after PGF_{2α}); and timed AI at 12 to 18 h after the second GnRH injection of the Ovsynch protocol.

²Unadjusted means are observed percentages. Adjusted means are based on logistic regression.

Those having a CDS of 1 or 2 had greater ($P < 0.05$) conception rates than those having a CDS of 3 or more (33.8 vs. 24.6%). Poorer fertility of cows having calving difficulty, because of its associated uterine pathology, is consistent with other reports (see review by Stevenson and Call, 1988).

Herd had no effect on pregnancy outcomes. All of the probability values for herd were >0.4 . This is attributed to both herds being fed the same TMR from a common feed supply, being managed under similar policies, and using common AI sires, even though different people detected estrus and performed inseminations at each dairy. Overall conception rates between herds differed by less than 0.5 percentage points.

Averaged across all treatment protocols, conception rates among lactation numbers tended to differ. No treatment $\times$ lactation number interaction was detected. First-lactation cows tended ($P = 0.10$) to have greater conception rates than did second-lactation cows (34.5 vs. 27.7%), and cows in their third or greater lactation tended ($P = 0.08$) to differ from conception rates of second-lactation cows (34.7 vs. 27.7%). Our results tend to confirm those in a recent study of 1584 lactating cows, in which first-lactation cows had greater conception rates than older cows when all inseminations were performed after an Ovsynch protocol (Tenhagen et al., 2004b). Furthermore, less fertile, older cows also produce more milk, which may account for some reduction in conception rates (Stevenson et al., 1983), although increased milk yields are confounded with age. That second-lactation cows had poorer conception rates in our study indicates that greater attention must be addressed to factors known to influence subsequent fertility, such as body condition (Moreira et al., 2000), feed intake (Staples et al., 1990), and other health issues during first lactations, first dry and subsequent transition periods, and early postpartum after second calvings (Stevenson, 2001).

General discussion. We have demonstrated that one of the challenges in implementing various reproductive-management schemes is compliance to protocols. Nearly 19% of the cows were inseminated off-protocol. This is not a concern for those cows in which inseminations occurred after detected estrus, but when TAI was administered to cows that received an improper injection sequence, pregnancy outcomes were compromised. Most serious infractions included those in which injections were given out of sequence, were given on the wrong dates, or were not given as designed. Compliance is difficult to monitor because documentation may be inaccurate or missing.

Our results show that cows inseminated after detected estrus at similar DIM are more fertile than those receiving TAI. Nonetheless, given the poor rates of de-

tected estrus (including missed observations and lack of estrus expression; Stevenson, 2001), TAI has proved to be an important tool for achieving pregnancies. In many studies, conception rates are nearly equal to or greater for cows inseminated after estrus, but pregnancy rates (no. of pregnancies $\div$ no. of cows attempted to AI) are often similar (Stevenson et al., 1996; Pursley et al., 1997a,b; Stevenson et al., 1999) or greater (Cartmill et al., 2001) because proportionally more cows of similar fertility are inseminated.

For cows inseminated at estrus at various DIM, those inseminated after 75 DIM had greater conception rates than those inseminated before 60 DIM. Establishing the appropriate VWP for individual herds is essential. Herd history for pregnancy outcomes after first services can be examined to determine if there is justification for delaying inseminations to achieve improved conception rates (Tenhagen et al., 2003). In earlier studies in which no ovulation control was employed, various VWP were tested. Most studies demonstrated nearly similar conception rates for cows inseminated earlier versus later postpartum, but cows inseminated earlier generally required more services per pregnancy (Whitmore et al., 1974; Britt, 1977), partly because that measure (services per pregnancy) does not account for services made for cows that fail to conceive and are eventually culled.

Evaluation of synchrony protocols should include reproductive performance traits (e.g., herd estrus-detection rates) in addition to costs of administering protocols. A recent study found that Ovsynch used to initiate first services improved reproductive performance in 2 herds (reduced days to first services and days open; reduced culling for infertility in one herd), but AI based on detected estrus was economically superior in another herd, whereas Ovsynch was superior in the second herd because of poorer estrus-detection rates (Tenhagen et al., 2004a). Days open and culling were the major cost factors of those evaluated in their economic analysis. Inseminations associated with Ovsynch (TAI) compared with those made after detected estrus in response to PGF_{2 α} has greater impact on net returns in summer months than during cooler months when estrus-detection rates tend to be greater (Risco et al., 1998).

Declining conception rates have been reported for lactating dairy cows since the 1950s, in the face of milk yields per cow, which have increased 3.3 times (Lucy, 2001; Stevenson, 2001). Our results indicate that the VWP should be extended in some herds to allow for improved fertility that may occur by delaying inseminations. Because of ovulation control and the benefits of increased persistency of lactation for cows treated with bST (Bauman et al., 1999), a shorter VWP seems less critical, particularly when a longer VWP may result in improved pregnancy outcomes. Using ovulation control

prevents prolonged and excessively variable intervals to first services (Stevenson, 2001). More importantly, because fewer than half of cows conceive at first AI, use of various tested resynchronization protocols for cows diagnosed not pregnant guarantees that cows are re-inseminated within 2 to 10 d of their not-pregnant diagnosis (Bartolome et al., 2003; Fricke et al., 2003; Stevenson et al., 2003; Stevenson and Tiffany, 2004).

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