Direct Comparison of Natural Service vs. Timed AI: Reproductive Efficiency and Economics

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Introduction

Despite the considerable advantages of artificial insemination (AI), a significant number of dairy producers use natural service (NS) for their breeding program. In a survey on bull management practices of California dairymen, 84 % reported use of NS as a component of their breeding program management (Champagne et al., 2002). The most common use of NS was after unsuccessful AI attempts. In dairy herds located in the northeast region of the US, reported use of NS, as a component of the breeding system, varied from 55 to 74 % (NAHMS, 2002; Smith et al., 2004). In a study that compared pregnancy rates **(PR)** between AI and NS in Georgia and Florida dairy herds, the use of NS alone or in combination with AI was reported to be around 70 % (De Vries et al., 2005). A survey that examined current management practices in 103 herds participating in the Alta Genetics (Watertown, WI) Advantage Progeny Testing Program, reported that 43 % of herds used a clean-up bull. Non-pregnant cows were moved to the clean-up pen after 6 failed AIs or 232 d postpartum. (Caraviello et al., 2006). A common perception among dairy producers that use NS is that more cows are bred by NS compared to AI because human errors in estrus detection are avoided when bulls are used. These producers also contend that a NS breeding program is cheaper and easier to manage than an AI program.

Bulls used for NS are under the influence of nutritional, environmental and management factors that may affect their ability to impregnate cows. Whether or not NS bulls classified as satisfactory potential breeder maintain reproductive soundness during the time that they are used for breeding is not known. With the understanding that bull fertility in an integration of biological as well as management factors, the potential for deviation in reproductive potential is possible.

Pregnancy rate is defined as the number of pregnant cows eligible to become pregnant over a specified period of time (every 21 days) and is the product of estrus detection and conception rate. A high PR at the end of the postpartum voluntary waiting period results in more cows pregnant earlier in lactation, maximizing farm income (Risco et al., 1998). Poor estrus detection is a major factor that contributes to low PR on many dairy farms in Florida and throughout the US. The use of NS and timed artificial insemination (TAI; cows are AI at a fixed time without being detected in estrus) are two options that minimize problems with estrus detection. This paper discusses research that compares reproductive performance between TAI and NS breeding systems.

NS vs. AI at detected estrus

Several studies have compared reproductive performance between AI at detected estrus and NS breeding systems. Seasonal effect on AI and NS fertility in dairy herds was evaluated under field conditions using Dairy Comp 305® (Valley Agricultural Software, Tulare, CA) (Niles et al., 2002). During periods of heat stress (summer), overall PR dropped for cows bred by either AI or NS, and no difference in PR was found between NS vs. AI bred cows during the cool season. In herds with poor estrous detection, NS resulted in a higher PR (Niles et al., 2002). The effects of four combinations of AI and NS breeding systems **(BS)** on production and reproduction responses were evaluated using Dairy Herd Improvement Association herd summary information (Smith et al., 2004). Herds were assigned to BS by percentage of NS usage as follows: 1) 0 %, 2) 1 to 20 %, 3) 21 to 89 %, and 4) 90 to 100 %. Actual calving interval was shorter in herds that used mostly NS (BS4) compared with other systems. However, herds using a combination of AI and NS or mostly NS had longer dry periods than herds using all AI. Days dry and the percentage of dry periods greater than 60 d were less for herds that used all AI breeding. Overall efficiency assessed by the percentage of cows in milk and herd milk yield was greater for herds that used all AI and declined as the percentage of NS increased. The effects of AI and NS BS on PR by stage of lactation and season over an 8 year time period showed that the use of NS bulls did not result in meaningful advantages or disadvantages in terms of PR over time (De Vries et al., 2005).

In contrast to the previously cited studies, a California study that compared calving to conception intervals for cows in AI pens with cows exposed to NS sires found that cows AI had a higher risk for pregnancy across all days in milk (**DIM**) (Overton and Sischo, 2005).

NS vs. timed AI: a field observation

A field observation is presented that demonstrates the ability of TAI and re-synchronized timed TAI to enhance herd PR in a large commercial dairy herd that utilized extensively NS (Thatcher et al., 2006). The herd was comprised of 2000 cows with approximately 1200 calving per year. Cows were housed in covered barns with self-locking stanchions and free-stalls.

Bulls used for NS underwent a breeding soundness exam and entered the NS program if classified as a satisfactory potential breeder according to the guidelines for the SFT (Chenoweth, 1992). Breeding soundness exams were repeated every 6 months and bulls that graded unsatisfactory were replaced. The BCR was one bull per twenty cows. The ratio in each pen was maintained based upon a monthly diagnosis of non-pregnant cow numbers. Bulls were rested for 14 d after 14 d of cow exposure. Cows more than 127 dim and diagnosed non-pregnant were identified. A decision was made to implement a timed AI program for these cows that were considered infertile (not pregnant by ample time exposure to bulls) in the NS program as described. The average day in milk was 356 for the 245 cows enrolled during the period from January 11 to June 21, 2006. The timed AI program entailed a presynchronization (i.e., two injections of $PGF_{2\alpha}$ given 14 d apart), followed by Ovsynch (i.e., GnRH given 14 d after the 2nd $PGF_{2\alpha}$ injection of presynchronization, followed by $PGF_{2\alpha}$ given 7 d after the first GnRH injection, and a second GnRH injection given 2 d after $PGF_{2\alpha}$ with a timed insemination between 16 to 20 h after the second GnRH), and a resynchronized timed AI with the Ovsynch protocol repeated in cows diagnosed open by ulstrasound at 32 d after the previous timed AI. Resynchronization was repeated twice in which cows went through three possible timed AI. This reproductive management sequence coordinated animal handling to 3 d of the week. As a population of infertile cows to NS, a cumulative PR of 56 % was obtained based upon ultrasound diagnosis at 32 d for the first three TAIs. At 60 d after insemination, 37.8 % of the inseminated cows were diagnosed pregnant via palpation per rectum. Pregnancy losses between d 32 and 60 were 32.5 %, which is substantial and reflects that the cows as a group were indeed sub fertile. Nevertheless, 37.8 % of the cows were pregnant that had not conceived through NS management. Although mean PR declined from first to third service (i.e., 37.5, 28.7 and 14.4 %, respectively), overall PR (i.e., either at day 32 or 60), did not differ for the intervals from 200 to 700 dim. The take home message from this field experience is that reproductive management centered on timed AI resulted in 38 % of subfertile cows becoming pregnant.

Direct comparison of timed AI vs. NS

A large study was recently completed in Florida comparing reproductive performance between two different breeding systems without estrous detection; TAI and NS (Lima et al., unpubl.). One thousand fifty five lactating Holstein dairy cows from a single farm located in north central Florida were randomized at 42 ± 3 d postpartum into two groups TAI (n=543) and NS (n = 512), and cows were blocked by parity (primiparous and multiparous).

Cows in the TAI group were pre-synchronized with 2 injections of $PGF_{2\alpha}$ (25 mg; Estroplan®, Pfizer Animal Health, New York, NY) given at 42 ± 3 and 56 ± 3 d postpartum. Fourteen days after the second $PGF_{2\alpha}$ cows were given an injection of GnRH (100 µg; Fertagyl®, Intervet Inc, Milboro, DE) followed 7 d later by an injection of $PGF_{2\alpha}$, and a second injection of GnRH 56 h after $PGF_{2\alpha}$. Timed AI was performed 16 h after the second injection of GnRH. Eighteen days after TAI, cows received a CIDR insert (Eazy-Breed; Pfizer Animal Health; New York, NY) followed by insert removal and GnRH administration 7 d later (25 d after TAI). Cows were diagnosed for pregnancy by ultrasonography examination at 32 d after TAI. The presence of an embryo with a heartbeat was the criterion for pregnancy. Cows diagnosed pregnant were re-examined by palpation per rectum of the uterus 28 d later (i.e., 60 d gestation) to reconfirm pregnancy status and to identify pregnancy loss. Cows diagnosed not pregnant at 32 d after TAI were administered $PGF_{2\alpha}$, followed with an injection of GnRH at 56 h after $PGF_{2\alpha}$. Timed AI was performed 16 h after GnRH. Cows not-pregnant were resynchronized again with the same protocol until diagnosed pregnant or at a maximum of 223 d postpartum.

Cows in the NS group received $PGF_{2\alpha}$ (25 mg; Estroplan®, Pfizer Animal Health, New York, NY) at d 42 ± 3 and 56 ± 3 and moved to a bull pen at 70 ± 3 d postpartum. The movement of cows into the bull pen 14 d after the last $PGF_{2\alpha}$ treatment (70 ± 3 d postpartum) was performed to synchronize estrus and bull breeding close to 80 d postpartum, i.e. similar to the TAI group. After 42 d of being turned in with bulls, cows underwent an ultrasonography examination to determine pregnancy status. This allowed a diagnosable gestation length in pregnant cows to vary from 28 to 42 d. The presence of an embryo with a heartbeat was the criterion for pregnancy between 28 to 34 d by ultrasonography, and gestation length from 35 to 42 was determined by size of the amniotic vesicle. Cows diagnosed not pregnant were re-evaluated for pregnancy status 28 d later to allow pregnancy diagnosis in cows pregnant < 28 at previous diagnosis (i.e. now 28 to 56 d of pregnancy), utilizing the same criteria described above. This procedure was similar for subsequent groups assigned weekly to the NS group. Cows diagnosed pregnant were re-confirmed 28 d later to identify pregnancy loss. The BCR in the NS herds was one bull per twenty open cows. Bulls were rested for 14 d after 14 d of cow exposure.All cows underwent a body condition score evaluation **(BCS)** at 70 ± 3 d postpartum prior to being introduced with bulls (NS group) or receiving the GnRH injection (TAI group).

Results are presented for data obtained during the cool and warm time of the year (November, 2006 to March, 2008). Outcomes of interest were rate of cows becoming pregnant up to 223 d postpartum. Days postpartum when pregnancy occurred was calculated by subtracting the days of pregnancy from the day postpartum when pregnancy was diagnosed. For example, a cow diagnosed pregnant 32 d at 130 d postpartum was pregnant at 98 d (i.e.130-32 d) postpartum. The interval between services in the timed AI group was 35 d due to the re-synchronization protocol employed. Therefore, for cows in the TAI group, d postpartum when pregnancy occurred to first, second, third or fourth service were classified as follows: d 80 ± 3 first service; d 115 ± 3 second service; d 150 ± 3 third service; and 185 ± 3 d for fourth service. For cows in the NS group, when pregnancy was diagnosed from 28 to 56 d, first, second, third or fourth services were classified at d 70 to 91, d 92 to 113, d 114 to 135 and 136 to 157 d postpartum, respectively. A cow in the NS group diagnosed 40 d pregnant at 150 d postpartum would have conceived at 110 d (i.e. 150 – 40 d) postpartum or at her second service.

Rate of pregnancy by day postpartum was analyzed with survival analysis using Cox's proportional hazards regression model (PROC LIFETEST and PROC PHREG, SAS, 2003 respectively). Categorical outcome variables such as first and second, service conception risk were analyzed using logistic regression PROC LOGISTIC of SAS 9.1; (SAS, 2003) with logit link and the appropriate distribution for dichotomous or count outcome variables (n=1055).

All models for reproductive outcomes included the main effects of treatment (NS vs. TAI), parity (primiparous vs. multiparous), BCS (≤2.75 or > 2.75), and season (Temperature Humidity Index [THI maximum ≥ 72]; Hot, April 22, 2007 to October 22, 2007; Cool, October 23, 2006 to April 21, 2007 and October 23, 2007 to March 13, 2008). Modeling was performed using stepwise selection logistic procedure with the significance level of entering (entry=0.30) and the significance level of stay (stay=0.20). The model fit statistics were performed by comparing the difference in the deviances by the likelihood-ratio statistic test.

Table 1 shows the PR to the first 2 services in cows bred by NS or TAI. During the cool season, first service and second service PR for NS (36.98%, 29.85%, respectively) and for TAI (44.31%, 30.67%, respectively) did not differ. As expected, PR to first and second service was lower during the warm season, but did not differ between NS and TAI (27.36%, 24.04%; 27.06, 29.56%; respectively). This finding agrees with those of Niles et al., 2002 that during periods of heat stress (summer), overall PR drops for cows bred by either AI or NS.

Median times to conception up to 223 DIM estimated from 32 d after breeding for TAI cows and 28 to 56 d for cows bred by NS were 109 d (95 % CI = 104 to 125) and 116 d (95 % CI = 115 to 117), respectively (Figure 1). There was no difference between the treatment (NS vs. TAI) survival curves. However, the rate when cows became pregnant during the first cycle at the end of the VWP between NS and TAI was different. For NS cows, PR to the first service cycle 21 days after bull exposure (70 to 91 DIM), was 33.0 % (cool and warm season) representing a PR of 1.57 cows / day. Conversely, for the TAI group, with a first service PR of 37% (cool and warm season) during the 10 days of the OvSynch and TAI protocol (70±3 to 80± 3 DIM), the PR was 3.7 cows per day. Figure 2 shows that 25 per cent of all pregnant cows conceived for NS at 84 DIM (95% CI=83to 86) and 81 days for TAI (95% CI = 80 to 82). We attribute this finding to the TAI management and not necessarily better fertility from TAI. In the NS group, pregnancy is dependent on the ability of the bull to identify cows in heat, breed, and impregnate them on a daily basis. When compared to NS, more cows are synchronized to be bred at a given acute service period in the TAI group. For the TAI group, it took five services for cows to become pregnant up to 223 DIM. In contrast, the NS group cows had more opportunities to be bred (at least 7 services) due to daily bull exposure and cows re-cycling every 21 to 23 days.

Body condition score for first service and parity to overall PR affected pregnancy. Cows with a BCS ≤ 2.75; had lower odds to conceive (AOR= 0.73; 95 % CI= 0.56 to 0.09; (PR=32.33%) compared to cows with a BCS > 2.75 had PR=38.85%. Primiparous cows had greater odds to conceive (AOR = 1.91; 95 % CI = 1.32 to 2.88 , PR= 87.32%) compared to primiparous cows(PR= 77.69%)

Critical to TAI programs is protocol compliance, semen handling and insemination technique. Pregnancy rates of 37 % to first TAI and 30 % to the re-synchronization (second service) of open cows indicate an acceptable response to TAI in the present study in a large commercial dairy setting that implemented a TAI program for the first time. We attribute the good reproductive performance obtained in the NS group to stringent bull management practices employed: bull selection, periodic breeding soundness evaluation of all bulls, removal of bulls that are not sound, and replacing unsound bullswith sound bulls, allowing for a two week cow exposure followed by a two week rest period, and BCR of 1:20.

Economic comparison NS vs. timed AI

An attempt was made to compare the costs and revenues of the NS program to the timed AI program in the direct comparison study. Partial budgets are in Tables 2 and 3. Labor costs and pregnancy rates in both programs were assumed equal based upon experimental results described above. The net cost of the NS program was a $92.29 per slot per year. For the timed AI program, the net cost was $51.61 per slot per year. Therefore, the NS program cost $40.68 per slot per year more, including an opportunity cost of $13.67 for less genetic progress. Without considering genetic progress, the NS program would cost $27.02 more per slot per year.

Overton (2005) calculated an extra cost of $10.27 per slot per year for a NS program compared to an AI program including 30% timed AI in large western Holstein dairy farms. He also assumed equal pregnancy rates. Overton assumed that for every 2 NS bulls, 1 extra cow could enter the herd. Thus, his AI program allowed for more cows than the NS program. When the number of cows in both programs was assumed equal, the extra cost per slot per year for a NS program was reduced to $3.61.

If there were differences in pregnancy rates between both programs as evaluated in this experiment, they could be easily incorporated into the partial budgets. An increase in pregnancy rate of 1 percentage point (e.g. 15% to 16%) is worth approximately $15 to $20 per slot per year with lower values at higher pregnancy rates (De Vries, 2007).

Conclusion

Cows sired by proven AI sires produced 1400 kg more herd lifetime actual milk and were $148 more profitable when compared to daughters of non-AI sires (Cassel et al., 2002). Despite this economic advantage of AI over NS, use of NS remains popular in many dairy herds. Studies evaluating reproductive performance between AI and NS do not show a clear disadvantage or advantage for using NS over AI. In herds with low PR related to poor estrous detection, uses of TAI or NS are viable options. Both of these breeding systems require strict attention to management compliance in order to optimize reproductive performance. Natural service breeding programs are expensive when direct and indirect costs are considered. Economic analysis within the content of this study showed that TAI is less expensive than NS and allows for immediate submission and a more rapid PR of all animals at the designated waiting period.

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Table 1. Pregnancy rate for first and second service in lactating dairy cows bred by NS or TAI. Season affected pregnancy but there was no season by treatment effect

	First service		Second service	
	NS	TAI	NS	TAI
Cool Season	36.98% (115)	44.31% (144)	29.85% (60)	30.67% (50)
Warm Season	27.36% (55)	27.06% (59)	24.03% (31)	29.56% (47)

Table 2. Partial budget of the NS program

		$ / per slot per year
Cows calving: 88%		
Purchase cost bulls	0.062 x 1148 =	(71.48)
Price per bull: $1148		
Bulls on dairy per cow: 0.060		
Average number of days bull is on farm: 354		
Total bulls needed entering herd per cow per year: 0.0062		
Additional bull cost after purchase	0.062 x 152.50 =	(9.50)
BSE, vaccines, other tests, per bull entering herd: $152.50		
Bull feed cost	(0.028 x 3.30 + 0.033 x 2.37) x 365 =	(61.67)
Cows:bull ratio in breeding pen: 38:1		
Bulls in resting pen: 0.028 per cow, bulls in breeding pen: 0.033 per cow		
Feed cost per day in breeding pen: $3.30		
Feed cost per day in resting pen: $2.37		
Feed cost per bull per year: $1021		
Sale revenues bulls	0.23 x 0.062 x 670 + 0.67 x 0.062 x 1116 =	63.10
23% bulls culled prematurely		
Sale price bull culled prematurely: $670		
Sale price bull culled healthy: $1116		
Labor cost bull management		(2.06)
Pregnancy check cost		(7.09)
Prostaglandin cost cows	0.88 x 2 x 2.035 =	(3.59)
2 shots at $2.035 per injection		
Net returns natural service program		(92.29)

Table 3. Partial budget of the timed AI program

		$ / slot per year
Cows calving: 88%		
Per cow entering experiment:		
Cows not pregnant after experiment: 15%		
Prostaglandin shots: 2.68 @ $2.035		
GnRH shots: 6.21 @ $1.84		
CIDR inserts: 2.68 @ $8.43		
Breedings: 2.68 @ 9.00		
Hormone and breeding cost		
Prostaglandin cost	0.88 x 2.68 x 2.035 x 1.15 =	(4.81)
GnRH cost	0.88 x 6.21 x 1.84 x 1.15 =	(10.09)
CIDR cost	0.88 x 2.68 x 8.43 x 1.15 =	(19.93)
Breeding cost	0.88 x 2.68 x 9.00 x 1.15 =	(21.28)
Genetic advantage AI sires	0.26 x 52 =	13.67
Calvings from 2nd or greater lactation cows: 64%		
Single heifer calves: 48%		
Heifer calves surviving until freshening: 85%		
Calves with a genetic advantage: 64% x 48% x 85% = 26%		
Average net merit AI sires: $361		
Average net merit NS sires: $163 (estimated)		
Time adjusted advantage net merit AI sires: (361-163)/3 x (1/1.08)^3 = $52		
Labor cost TAI		(2.06)
Pregnancy check cost		(7.09)
Net returns timed AI program		(51.61)

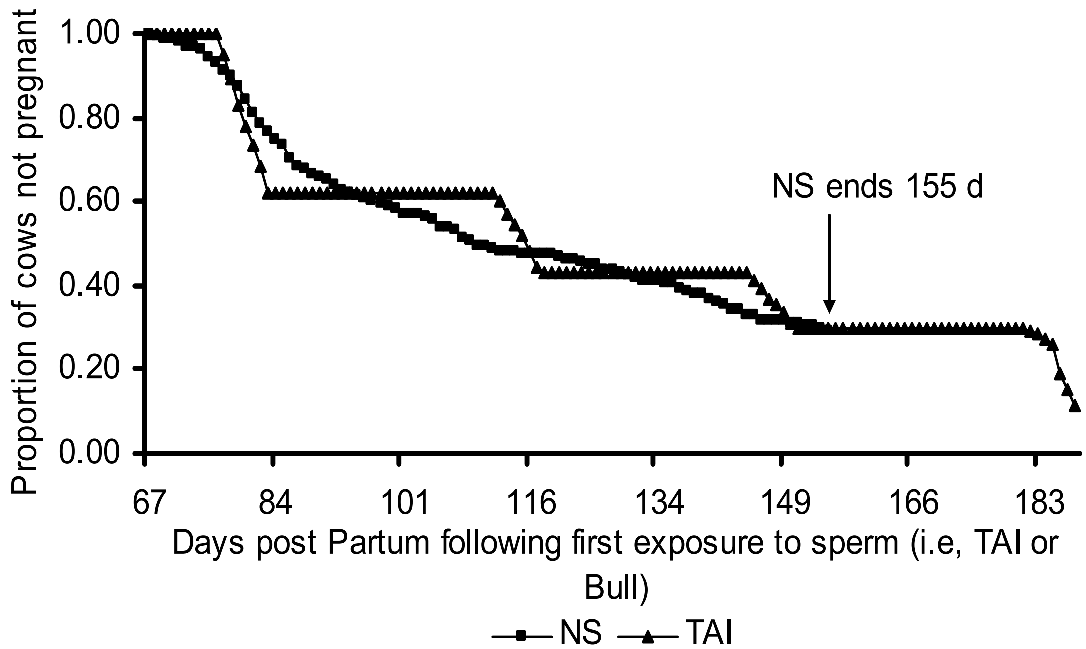

Figure 1. Survival curves for accumulated open cows based on an ultrasound pregnancy diagnosis at D32 for timed AI (▲) cows and cows bred by NS (■) following four services. Median times to conception up to 223 DIM estimated from 32 d after breeding for TAI cows and 28 to 56 d for cows bred by NS were 109 d (95 % CI = 104 to 125) and 116 d (95 % CI = 115 to 117), respectively.

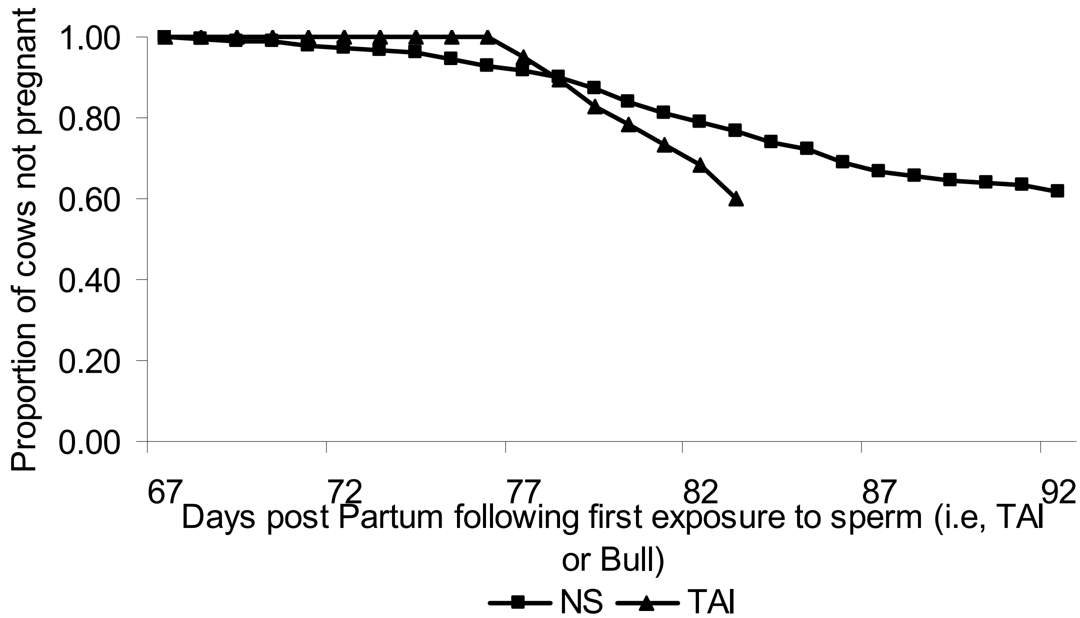

Figure 2. Survival curves for accumulated open cows based on an US pregnancy diagnosis at d 32 for TAI (▲) and d 28-56 for NS (■) for first service. Twenty five per cent of all pregnant cows conceived for NS at 84 DIM (95% CI=83to 86) and 81 days for TAI (95% CI = 80 to 82).

Notes