Reproductive Efficiency and Economics of Timed AI vs. Natural Service

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Introduction

Despite the advantages of artificial insemination (AI), natural service (NS) continues to be commonly used by dairy producers. A California survey revealed that 84% of dairyman use NS as a component of their breeding program management (Champagne et al., 2002). 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 close to 70% (deVries 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 (Caraviello et al., 2006).

The main reason for using NS in dairy operations in the previously cited reports is the notion that more cows are bred by bulls compared to AI because human errors in heat detection are avoided when bulls are used. Systematic breeding programs for AI at a predetermined time (Timed AI; TAI), without the need for heat detection, coupled with early rebreeding of non-pregnant cows are successful options for reproductive management of lactating dairy cows. These systems optimize PR by synchronizing follicle development, regression of the CL, and precise induction of ovulation to provide a fixed TAI (Pursley et al., 1997; Thatcher et al., 2000, 2001 a, b, 2002). Incorporation of TAI in dairy herd reproductive management programs reduces labor requirements for heat detection while improving overall reproductive performance and maximizing profit (Risco et al.,1998 a, b). However, studies that compare reproductive performance between NS and TAI, two breeding systems where heat detection is not a factor are lacking.

This manuscript discusses methods that veterinarians and producers can use to improve management of NS breeding programs in dairy herds to optimize PR. Also, research that compared reproductive performance and economics between AI and NS breeding systems is presented.

Bull Selection

Bulls for use in NS should be carefully selected for their primary task, which is to get cows pregnant. The ability of bulls to perform this task is dependent upon their semen quality, libido, mating ability and social ranking among bulls and cows. Therefore, as with beef bulls, it is recommended that NS bulls pass a breeding soundness evaluation, as recommended by the American Society for Theriogenology and repeated, at least, on an annual basis (Chenoweth P., 1992). In hot summer months, some reduction of bull fertility may be expected due to lowered semen quality associated with an increase in abnormal sperms. Breeding activity, a function shared by both males and females, is usually less during the hotter parts of the day in summer, although this is rectified during cooler periods. As females tend to exhibit lower estral behavior during hot weather, the inherent bull advantage in heat detection should compensate, at least in part, for lowered semen quality. Young bulls (2.5 years or less) are recommended because of the difficulties and dangers of handling older bulls on dairy farms. These young bulls should be fully pubertal (for Holsteins over 14 months of age) and of a size compatible with the cows that they need to service. However, younger bulls should not be used at low bull to cow ratios (BCR) as their reproductive capacity is not generally as high as that of older bulls.

Economic losses that occur from use of NS bulls due to the loss of potential genetic progress in milk yield are high. In the US, sire-of daughter pathway was shown to be the weakest area of genetic improvement because of extensive use of NS bulls with low genetic merit. To help reduce these losses from genetically inferior NS bulls, producers should consider using bulls for NS that are good enough for AI sampling. Dairy herds that exclusively use NS usually do not raise replacement heifers. Here, genetic improvement of the herd can be achieved by purchasing replacement heifers from breeders who are using AI with semen from proven bulls.

Bull Management

With the understanding that bull fertility is an integration of biological and management factors, the potential for deviation in an expected level of fertility from bulls can occur if they are not properly managed. The problem is that research on management strategies to optimize fertility in dairy farms that use NS is lacking. Consequently, management recommendations have been made from research conducted on beef bulls and from experiences working with dairy clients who successfully manage NS (Overton et al., 2003; Risco et al., 1998).

Bulls should be subject to the same vaccinations as cows (except for brucellosis and thrichomonosis), as well as the same treatments for parasites. Control of venereal diseases is essential to the success of NS. It is recommended that cows be vaccinated for vibriosis at least three weeks prior to breeding and receive a booster at 6 month intervals. Some success has also been reported with bull vaccination (Vasquez et al., 1983). Vaccination is also available for trichomonosis, but in breeding cows only. All bulls in production should be checked for trichomonosis at the time of the breeding soundness evaluation.

Obesity and lameness can negatively impact reproductive performance. Rations which are balanced for middle to high producing dairy cows contain higher energy, protein and calcium levels than those required by the bull. The excess in energy intake can predispose the bull to over conditioning and laminitis. Feeding bulls a high level of dietary calcium has been associated with lameness in conjunction with bone lesions in the spine and hip regions. The dietary requirements for mature bulls regardless of genotype are similar to requirements of a dry dairy cow. Major determinants for lameness in bulls include feeding a lactating cow diet, which can contribute to laminitis, and confinement on hard unstable surfaces (e.g. concrete) for long periods of time. To avoid problems related to a lactating cow ration, evaluation of body condition and lameness should be conducted frequently in NS bulls. Factors which can reduce lameness in bulls include periodic rest, removal from concrete and feeding a dry-cow type ration.

In many dairy regions of the United States as much as 8 pounds (15% of ration dry matter) of whole cottonseed is fed in total mixed rations balanced for high producing dairy cattle. Thus, a mature Holstein bull with a dry matter intake of 13 kg could consume as much as 13 g of free gossypol per day. Whether or not gossypol intake at this level has a detrimental effect on bull fertility is not definitively known. An increase in sperm midpiece abnormality and a reduction in sperm production in Brahman bulls fed 2.75 kg of cottonseed meal (8.2 g of free gossypol per day) has been reported (Risco et al., 1993; Chenoweth et al., 2000) . In contrast, Hereford bulls ingesting 7.6 to 19.8 g of free gossypol daily from whole cottonseed showed no significant sperm abnormalities (Cusak et al., 1995). The type of cottonseed product (meal vs. whole seed) fed may determine the extent of the toxicological effect as detoxification of gossypol in the rumen is more efficient with whole seed diets than with cottonseed meal diets.

The BCR is an important aspect of bull management. In contrast to beef herds, the optimal stocking ratio for dairy herds is not known, but probably differs depending upon housing environment and level of management. Overton et al. (2003), has suggested that for dry lot or pasture dairies, assuming that dairies will continue using young bulls, the proper BCR is most likely a 1 healthy and fertile bull per 20-25 non-pregnant cows, depending upon whether or not the cows have been synchronized before entering the pen. For free stall dairies, more bulls are likely required and a BCR of 1:15-20 non-pregnant cows is suggested.

Social effects may strongly influence bull reproductive success. With multi-sire groups, bulls lower in dominance rank may be inhibited by bulls of higher rank. In general, social rank is most influenced by age, or seniority, although body size, presence of horns and breed may also be important. The most serious effects of adverse bull interactions may be avoided by employing homogenous groups of younger bulls. However, as older females may also inhibit inexperienced young bulls, it is wise to monitor breeding activity, at least initially.

Safety is a major concern with bulls on dairy farms, partly because dairies often do not have adequate facilities, or personnel training, for bull handling. Bulls should be monitored for attitude and bad temperament should be a reason or excuse for culling. Due to a better temperament, younger bulls should be used and strict adherence to safety protocols must be followed. Accidents occur when people cut corners with safety protocols, particularly when they assume that a particular bull is safe. As bulls become more agitated (and dangerous) when separated, it is advisable to keep them within groups as much as possible.

An example of a bull management program developed by Dairy Production Systems of Florida (High Springs, Florida; http://dpsdairy.com) is shown in the sidebar and is printed with their permission.

All new bulls:

All purchased bulls should be mouthed for age. Bulls greater than 18 mo of age should be rejected. All bulls must weigh 700-800 lb at the time of purchase and each bull should have its own unique identification number.

- Perform a Breeding Soundness Examination (**BSE**), test for trichomonosis and test for PI BVD by ear notch method.
- Vaccinations:
  IBR/BVD/PI3 & BRSV (Modified Live Vaccine) + 5-way Lepto and L. borgpetersenii. Repeat initial vaccination in 3 weeks.
  Clostridium 8-way
  Vibrio (Oil adjuvant): Revaccinate with Vibrio vaccine every 3 months.
- Parasite Control:
- Deworm and Delouse: Repeat 3 weeks after first application

Current breeding bulls (exposed to lactating cows)

- All bulls must have a complete BSE every 6 months. After initial processing and clearance, bulls should be used for 6 months. After 6 months bulls should be re-tested and if satisfactory, they are used for another 6 months, after which the bull is culled.
- No bull is to be used in service for more than 12 months.
- Bulls are revaccinated at 6 mo. BSE check for Vibrio and the other vaccines are boostered in concert with the lactating herd.
- Bulls must be checked daily for lameness and any other health disorders. If a bull is lame, he should be removed from the cow herd and treated accordingly. He should be replaced immediately by a sound bull.
- Keep a minimum of 10 bulls in the resting pen ready to relieve any ill or lame bull. (These additional "bulls-in-reserve" represent about 10 % of the normal working population.)
- Monitor attitude daily. Any bull that becomes aggressive or difficult to handle must be culled ASAP.
- Check daily to make sure that bulls are in the correct pens and that bull-to-cow ratios are correct. Bulls should be rotated and rested after 14 d. Maintain 1 bull for every 20 open cows in each pen. After each palpation week, re-evaluate these ratios and adjust accordingly.
- Resting bulls receive the lactating cow TMR refusals (tends to be higher in fiber and contains less cottonseed and energy as the original feed, but yet decreases the risks associated with wholesale ration changes)

Reproductive management of cows

In herds that use only NS the advantages of a fresh herd and a voluntary waiting period of 60 days should be considered. Fresh cows can be monitored daily for health and sick cows treated promptly without the nuisance of having a bull present. The fresh herd also allows a well balanced postpartum transition diet to be fed to reduce metabolic or digestive disorders. In a fresh herd, prostaglandin ($PGF_{2\alpha}$) can be used to promote multiple cycles and uterine involution during postpartum in an attempt to increase pregnancy rate at first service. To help reduce the interval from calving to first service cows may be treated with $PGF_{2\alpha}$ prior to being exposed to the bull.

Breeding dates are not known in many NS herds and consequently days pregnant have to be estimated which results in too long or short dry periods. Palpation estimates of days pregnant are most accurate when cows are less than 65 days pregnant. The date when cows are first turned with the bull and the last examination date at which the cow was found open are important information for estimating days pregnant in cows bred by NS. Pregnancy diagnosis can be performed in cows 40 to 60 days after being turned with the bull. Cows that are open at pregnancy test can then be re-examined 30 days later. Cows that are found to be cystic can be treated with GnRH; use of $PGF_{2\alpha}$ should be limited to cows with pyometra only. To monitor the presence of trichomonosis in a herd, it is beneficial to re-confirm pregnant cows around 120 days of gestation. Abortions due to T. foetus occurs during the first trimester of gestation and rarely after 5 months of gestation Pyometra may be present in up to 10 percent of the cows in an outbreak of trichomonosis. Trichomonad pyometra is postcoital and not postpartum, but can occur after death of the developing embryo or early fetus. Cows with pyometra in NS herds should be cultured for T. foetus. Pregnancy in cows should also be reconfirmed prior to dry off similar to the practice used in A.I. herd around 180 to 200 days postpartum.

Economic Considerations of TAI and NS

A study conducted in Florida, modeled potential net returns per cow by comparing use of TAI in winter and summer compared to insemination at detected estrus (Risco et al., 1998b). The greatest impacts on net returns were obtained when TAI was used during summer compared to winter. This finding was attributed to lower estrous detection rates observed during the summer months. It was concluded that use of a TAI program such as Ovsynch is an economical alternative in reproductive management of dairy herds with poor estrous detection. A TAI protocol using OvSynch was compared to AI at detected estrus in 2 large dairy herds differing in reproductive management (Tenhagen et al., 2004). Use of OvSynch reduced intervals to first AI and days open in both herds, as well as culling for infertility in herd 2. Conception rates for first AI at detected estrus were significantly higher compared to TAI in both herds and for overall inseminations at estrus in herd 2. For groups assigned to AI at estrus, mean 21-d submission rates over 200 d for AI were higher in herd 1 than in herd 2 (55.6 vs. 28.6 %). Days open and culling were the major cost factors. Although OvSynch improved reproduction in both herds, AI based on detected estrus was economically superior in herd 1, whereas OvSynch was superior in herd 2. The authors concluded that evaluation of synchrony protocols should consider reproductive performance along with costs associated with treatments. Such costs may offset benefits to reproduction in herds with good estrous detection rates.

A study conducted by Overton and Sischo (2005), used a partial budget approach to stochastically model the expected costs and return of reproductive management option in large western Holstein dairies. Two options were considered in the model. Option one, NS sires managed using recommended approaches such as BSE's, vaccinations and a rotational (rest) breeding system. Option two, included an AI system using a modified Presynch-OvSynch TAI program in conjunction with estrous detection and AI performed by professional itinerant breeders. The cost of the lactating ration, purchased cost of bulls, milk price, market value of bulls and net merit gains were considered as stochastic variables. The model showed that NS averaged approximately $10 (USA) more in cost per cow per year compared to AI. However, there was a wide variation in expected differences in cost between the two breeding systems. Net merit estimates of bulls used for AI, prices received for milk sold, and market price of bulls, in that order, had the greatest impact on costs between AI and NS breeding systems. Overton (2005) also calculated an extra cost of $10.27 per slot per year for a NS program compared to an AI program including 30% TAI in large western Holstein dairy farms. He also assumed equal pregnancy rates. Overton assumed that for every two NS bulls, one 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.

A simulation study conducted in Greece evaluated data from 120 dairy farms to compare the costs associated with breeding dairy cattle by AI or NS (Valergakis et al., 2007). Calculations were based on direct AI and NS costs, and costs associated with an extended calving interval scenario for both breeding systems. Bull maintenance costs were from $1000 to $2100. Direct AI costs were higher for NS than AI for farms with more than 30 cows and extended calving interval resulted in major economic losses. Hypothetically, when use of NS resulted in a calving interval of 12 months, AI daughters with a calving interval of 13.5 months have to produce about 705 kg of additional milk to cover extra costs. Their actual milk production exceeded this limit by more than 25 %. When real calving intervals were considered (13.0 vs. 13.7 months for NS and AI, respectively) AI daughters produced more than twice the additional amount of milk needed. It was concluded that under less than average management conditions, AI is more profitable than the best NS scenario.

Studies Comparing 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 (deVries 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 (Overton and Sischo, 2005).

NS vs. Timed Artificial Insemination

A large study was conducted in Florida that compared reproductive performance between two different breeding systems without heat 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 re-synchronized 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 used for one year and underwent a breeding soundness evaluation according to the American Society for Theriogenology prior to cow exposure and thereafter, every three months. Bulls classified as unsatisfactory (not sound) were removed and replaced with sound bulls. In addition, bulls were rested for 14 days after 14 days 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).

Outcomes of interest were days to pregnancy up to 223 days postpartum and PR per 21 day cycle (# pregnant/# eligible every 21 days). In cows bred by NS, 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, day 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.

Days to pregnancy was analyzed by survival analysis and conception risk using logistic regression. 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).

Table 1 shows the PR to the first two 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, PR dropped during the warm season, but no difference was found for cows bred by AI or NS.

The proportion of pregnant cows by 223 d postpartum which was the end point of the study, was greater for NS than for TAI (NS=84.8% and TAI=76.4%, p=0.009). The median time to pregnancy by 223 d postpartum was shorter for NS bred cows (111 days [95% CI = 104 to 125] than TAI bred cows (116 days [95% CI = 115 to 117]) and is shown in Figure 1. The curves do not differ until 150 d postpartum, thereafter the two curves differ with a greater cumulative PR for the NS group. 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 service period in the TAI group. For the TAI group, it took five services for cows to become pregnant by 223 DIM. In contrast, cows in the NS group had more opportunities to be bred (at least 8 services) due to daily bull exposure and open cows re-cycling every 21. Reproductive outcomes are shown on table 2. Pregnancy rate per 21 days cycle were not different between TAI and NS (24.2% and 25.1%,; respectively, p = 0.93).

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 which had a PR of 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 Florida study. We attribute the good reproductive performance obtained in the NS group to stringent bull management practices employed; bull selection, periodic BSE's of all bulls, removal of bulls that were not sound, and replacing unsound bulls with sound bulls, allowing for a two week rest period, and a BCR of 1:20.

The costs and revenues of the NS program were compared to the TAI program in the Florida study. Partial budgets analysis was performed that considered explicit and implicit costs. Explicit costs were all accounting expenses that involve an actual cash payment. Implicit costs are an opportunity cost of foregone milk production that does not involve a cash payment. In the NS group, the following variables were used to evaluate explicit costs: price of purchase or production cost of bulls, management cost, housing cost, vaccination cost and feed cost of bulls, replacement cost of bulls culled prematurely, cost of BVD testing, cost of $PGF_{2\alpha}$ to prevent uterine problems, health cost, cost of a breeding soundness evaluation and bull market return. In the TAI group, the following variables were used to evaluate explicit costs: cost of hormones used in the pre-synchronization, synchronization and re-synchronization protocols, cost of semen, cost of supplies to perform insemination and labor cost to perform AI. To evaluate implicit costs, the following variables were used: costs merit of genetic gain expected for NS and TAI based on the net merit for young sires and proven bulls used in TAI and net merit for NS sires for bulls used in NS breeding system. Labor costs and pregnancy rates in both programs were assumed equal. The net cost of the NS program was $92.29 per cow slot per year. For the TAI program, the net cost was $59.82 per cow slot per year. Therefore, the NS program cost $32.47 per slot per year more. Net merit estimates of bulls used for AI and feed cost for NS bulls had the greatest impact on costs between AI and NS breeding systems.

Conclusion

In herds with low PR related to poor heat detection, the use 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. Utilization of TAI is less expensive than NS and allows for immediate submission rate 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)

Figure 1. Survival curves for proportion of non pregnant cows by days postpartum. The median time to pregnancy by 223 d postpartum was shorter for NS bred cows (111 days [95% CI = 104 to 125] than TAI bred cows (116 days [95% CI = 115 to 117])

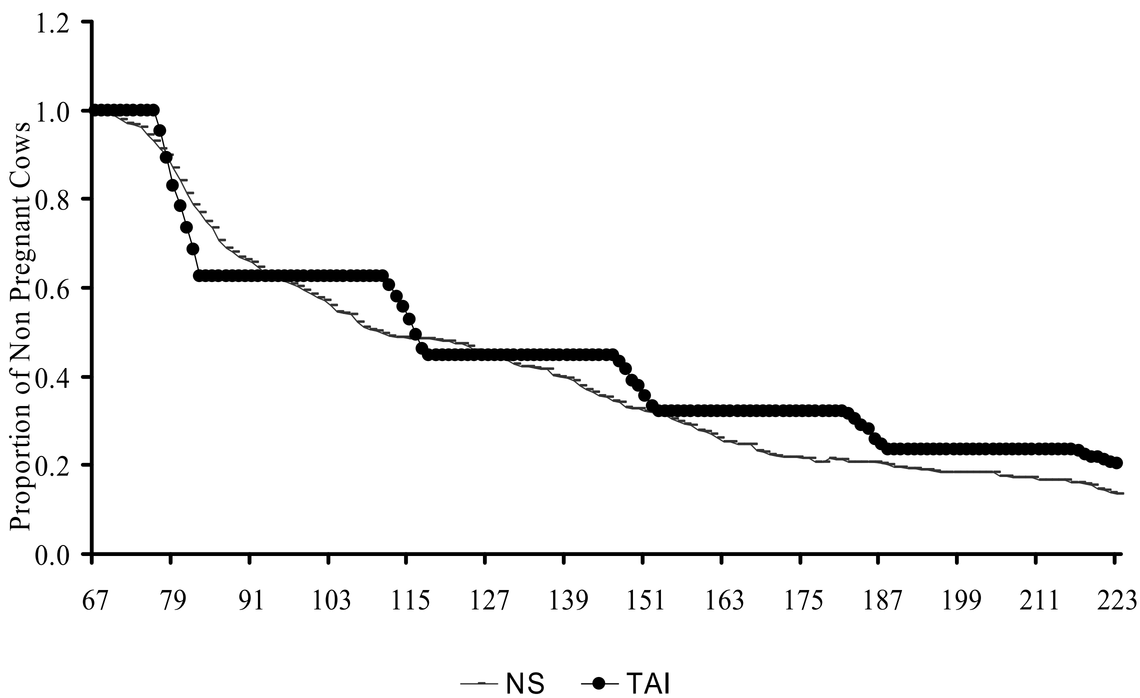

Figure 2. Survival curves for proportion of non pregnant cows based on an US pregnancy diagnosis at d 32 for cows bred by TAI (▲) and d 28-56 for cows bred by NS (■) to first service. Twenty five per cent of all pregnant cows conceived for NS at 84 DIM (95% CI=83 to 86) and 81 days for TAI (95% CI =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

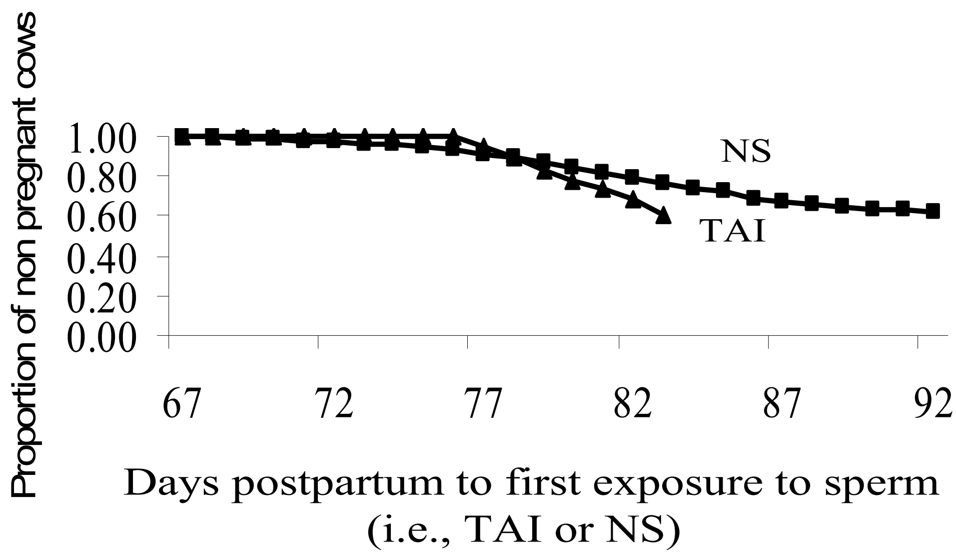

Table 2. Reproductive responses for cows bred by TAI or NS

Variables	**TAI**	**NS**
Cows inseminated or exposed to the bulls by 223 DIM	543	512
Proportion of cows pregnant in the 1st 21 d breeding	37.4 %	34.4 %
Cows pregnant by 223 DIM	415 (76.4 %)[b]	434 (84.8 %)[a]
Mean days open in pregnant cows (± SEM)	113.2 ± 2.0	115.9 ± 1.9
Median days open	116[a]	111[b]
Cow-days at risk1	29,424	30,978
Pregnancies/1,000 cow-days at risk	14.10	14.00
21-d cycle pregnancy rate, %	24.2	25.1

[a,b] Superscripts in the same row differ ($P < 0.05$)
[1] Cumulative number of days for cows between exposure to bulls and pregnancy or end of study in NS, and between first service and pregnancy or end of study in TAI.