Management and economical considerations of timed artificial insemination and natural service breeding programs in dairy herds

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Introduction

Artificial insemination (AI) has proven to be a reliable technology for dairy producers to make genetic progress and control venereal diseases in their herds. However, despite these advantages many dairy producers prefer to use natural service (NS) as a component of their herd’s breeding program.1-5 Producers that use NS believe that more cows can be bred by NS than AI because human errors in estrus detection are avoided when bulls are used. However, several studies have shown that this perceived increased in estrus detection and thus more cows bred when bulls are used, does not result in better reproductive performance when compared to AI.4,6 Furthermore, the development of breeding programs for AI at a predetermined time (timed AI; TAI), without the need for estrus detection has evolved in the last fifteen years as a successful strategy for reproductive management of lactating dairy cows.7-9

Dairy producers must consider that a successful reproductive program based on NS is dependent on fertile bulls that require proper management which can be labor intensive. In this manuscript, methods to manage NS breeding programs are discussed and research that compared reproductive performance and economics between TAI and NS breeding systems is reviewed.

Keywords: Artificial insemination, natural service, reproductive efficiency, reproductive management

Management considerations for natural service herds

Research on management strategies to optimize fertility in bulls used for NS in dairy herds is lacking.10 Overton et al11 reported that recommendations to use NS bulls in dairies are made from research conducted on beef bulls and from experiences working with dairy clients who successfully manage bulls. The ability of a bull to impregnate cows is dependent on semen quality, libido, mating ability and social ranking among other bulls and females.12 Therefore, a breeding soundness evaluation (BSE), as recommended by the Society for Theriogenology,13 is fundamental and only bulls classified as a potential satisfactory breeder should be used. A BSE should be performed in all bulls prior to cow exposure and should be repeated every six months to determine whether or not bulls maintain their reproductive soundness during cow exposure over time. As a component of the BSE, testing for the venereal diseases trichomoniasis and campylobacteriosis (vibriosis) is highly recommended. Young bulls (2 to 2.5 years) should be used because of their temperament and lower risk for venereal disease transmission.14 Young bulls should have achieved full puberty and sexual maturity, which occurs around 14 months of age, and should not be undersized in relation to a mature Holstein cow.

Bulls should undergo the same vaccination (except for brucellosis and Tritrichomonas foetus) and parasite control practices as cows. Control of venereal diseases is essential to the success of NS breeding programs. Cows should be vaccinated for campylobacteriosis at least three weeks prior to being exposed to bulls and receive a booster at intervals of six months. Bulls can also be vaccinated for campylobacteriosis, with some success reported using twice the recommended dose for a cow.14 Vaccination is also available for Tritrichomonas foetus in cows. The bull to open cow ratio (BCR) is an important management factor in herds that use NS. Champagne et al1 reported that 53% of California dairymen surveyed used bulls at the ratio of 1 bull per 30 or fewer non-pregnant cows. The most common BCR reported was 1:20-25 total cows in the pen. Although, the optimal BCR for dairy herds has not been evaluated, housing type and environment are important considerations. For dry lot or pasture dairies, the BCR is most likely 1 to 20, but for free stall dairies more bulls are recommended and a BCR of 1:15-20 has been suggested.11 Because safety should be a major concern with bulls on dairy farms, those bulls that exhibit a bad temperament should be culled. Other safety precautions include the use of younger bulls and strict adherence to safety protocols.
An example of a bull management program developed by Dairy Production Systems of Florida (High Springs, Florida; http://dpsdairy.com) is shown below with their permission.

All new bulls:

All purchased bulls should be mouthed for age. Bulls older than 18 months 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 BSE, test for trichomoniasis 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
  - Campylobacter (oil adjuvant): Revaccinate with campylobacter 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 receive BSE, trichomoniasis test, re-vaccination for campylobacter each 6 months. 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 herd and treated accordingly and 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 immediately.
- 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)

A NS breeding program allows for the implementation of important management practices such as a postpartum herd without bull presence with a designated voluntary waiting period. A postpartum herd allows for cows to be monitored daily for health, and sick cows treated promptly without the nuisance of having a bull present. The postpartum herd also allows a well-balanced transition diet to be fed to help control metabolic or digestive disorders. Furthermore, prostaglandin F2α (PGF) can be administered to cows prior to being exposed to bulls to help synchronize estrual events.

In cows bred by NS, accurate estimation of gestation length may be difficult and results in cows not receiving an appropriate dry period which can affect cow performance after calving. The length of the dry period was associated with udder health, culling, and overall performance during early lactation. Extended dry periods of 143 to 250 days increased the likelihood of subclinical mastitis during early lactation.
lactation and had a negative impact on reproductive performance. Short (0 to 30 d) and extended (90 days) dry periods had a detrimental impact on early lactation and 305 day milk yield and increased the risk of overall culling when compared to a conventional dry period of 53 to 76 days. Estimates of days pregnant obtained from palpation are reliable from 32 to 90 d. Assuming that a pregnancy diagnosis of 32 days is the earliest that can be performed, the interval between examinations of non-pregnant cows should not be greater than 60 days. In this manner, a cow that is less than 32 d pregnant and is diagnosed non-pregnant would be between 61 to 91 days pregnant when re-confirmed 60 days later. The date of the last examination at which the cow was diagnosed not pregnant is important information for estimating gestation length. Cows that are found to be cystic can be treated with gonadotropin-releasing hormone (GnRH); use of PGF should be limited only to cows with pyometra. To monitor the presence of trichomoniasis in a herd, some practitioners have found it beneficial to re-confirm pregnant cows between 90 to 120 d of gestation. Abortions due to *Tritrichomonas foetus* occur during the first trimester of gestation and rarely after five months of gestation. Pyometra may be present in up to 10 percent of the cows in an outbreak of trichomoniasis. Therefore, it is strongly recommended that during routine reproductive examination, cows diagnosed with pyometra should be cultured for *Tritrichomonas foetus*. Trichomonad pyometra is post-coital and not postpartum and occurs after death of the developing embryo or early fetus. Pregnancy in cows should also be re-confirmed prior to dry off similar to the practice used in AI herds.

**Reproductive performance of timed AI vs. natural service**

Natural service and TAI are two breeding programs that can be used by dairy producers to avoid detection of estrus to breed cows by AI. Lima et al. compared reproductive performance between NS and TAI bred lactating dairy cows. Cows were randomly allocated to a NS or TAI group. Cows in both groups were presynchronized with two injections of PGF given 14 days a part. Fourteen days after the last PGF injection, cows in the TAI group were enrolled in an Ovsynch program (d 0 GnRH; 7 d later, PGF; 56 h after PGF injection, second dose of GnRH; and 16 h after second GnRH cows were TAI). All cows in the TAI group received an intravaginal device containing progesterone inserted 18 days after TAI and GnRH on day 25 after AI as part of an aggressive strategy to resynchronize cows shortly after pregnancy diagnosis. Cows were examined by ultrasonography on day 32 after TAI; non-pregnant cows received PGF and GnRH 56 h later followed by TAI 16 h after the GnRH injection. Non-pregnant cows in the TAI group were re-synchronized and re-inseminated up to five times using the same program.

Cows in the NS group were exposed to bulls 14 days after the second PGF injection, and ultrasonography was performed on day 42 after exposure to bulls to determine pregnancy status. Non-pregnant cows in the NS group were reexamined by transrectal palpation combined with ultrasound every 28 days until diagnosed pregnant or 223 days postpartum, or whichever occurred first. Cows diagnosed pregnant in TAI or NS were re-examined 28 days later to determine pregnancy loss.

Bulls underwent a BSE and entered the NS program if classified as a satisfactory potential breeder according to the guidelines of the Society for Theriogenology. Breeding soundness evaluations were repeated every three months and bulls that graded unsatisfactory were replaced. The BCR was one bull per twenty cows, the ratio in each pen was maintained based on the number of cows diagnosed non-pregnant. Bulls were rested for 14 days after 14 days of cow exposure, were vaccinated according to farm standard operating procedures and removed from the herd after 12 months of use. Blood was collected from cows and analyzed for progesterone to determine cyclic status and body condition scored at day 70 postpartum.

The overall 21-day cycle pregnancy rate was not different between groups (25.7 and 25.0% for NS and TAI, respectively). The adjusted hazard ratio (AHR) for pregnancy was greater for NS than TAI (Figure), which resulted in fewer median days open (111 vs. 116 days). Proportion of pregnant cows at 223 days postpartum was greater in the NS than TAI group (84.2 vs. 74.8%, respectively). Cyclicity did not affect reproductive responses. Cows with a body condition score ≥2.75 had a greater proportion of pregnant cows in the first 21 days of breeding and AHR for pregnancy in the first 223 days postpartum.
Primiparous cows had greater proportion of pregnant cows and AHR than multiparous cows at 223 days postpartum.

The dynamics of the NS reproductive program allowed all eligible cows to have a breeding opportunity every 21 days which allowed cows in this group to have up to eight breeding opportunities until 223 days postpartum which was the endpoint for the study. On the other hand, cows enrolled in the TAI program due to the strategy of only TAI, breeding opportunities only occurred every 35 days, allowing for a maximum of five breeding opportunities until the end of the study at 223 days postpartum. Therefore, the greater proportion of pregnant cows in the NS group was a result of increased number of opportunities for breeding occurring in this program in comparison to the TAI group. Nonetheless, the most common measurement of reproductive performance, the 21-d cycle pregnancy rate was not different.

A second study was conducted in Florida in which all cows were TAI for the first service and then either were exposed to NS one week later or were TAI up to three times before being moved to a NS group. In this study, all cows received a double Ovsynch TAI program (d -27 GnRH, d -20 PGF, d -17 GnRH, d -10 GnRH, d -3 PGF, d -1 GnRH, and d 0 AI) for first AI. On the day of first AI, cows were blocked by parity and randomly assigned to receive one (1TAI) or 3 TAI (3TAI) before being moved to a NS pen. Cows in the 1TAI treatment were moved to NS seven d after the first AI and cows in the 3TAI treatment seven d after the third TAI. Pregnancy status was determined 32 days after TAI and every 28 days in the NS herds after the previous non-pregnant diagnosis.

Non-pregnant cows in the 3TAI group were resynchronized with the Ovsynch program starting on day 32 after the previous insemination, such that the re-insemination interval was 42 days. Pregnant cows were re-evaluated for pregnancy 28 days after the initial diagnosis. Cows were scored for body condition 32 days after the first AI. All cows had a period of 231 days after the first AI. As expected, pregnancy at the first TAI did not differ between 1TAI and 3TAI on day 60 after insemination (3TAI=33.4 % vs 1TAI=31.5 %). Cows receiving 3TAI had 15% greater AHR for pregnancy than 1TAI. This resulted in smaller median days open for 3TAI than for 1TAI (3TAI=123 d vs 1TAI=143 d). The proportion of pregnant cows in the first 21 days was not different (3TAI=33.6 % and 1TAI=32.6 %). Nonetheless, the proportion of pregnant cows in the 42 days was greater for 3TAI than for 1TAI (3TAI=51.4 % vs 1TAI=41.5 %). The 21-day cycle pregnancy rate was greater for 3TAI than 1 TAI (3TAI=26.7 % vs 1TAI=23.6 %). Therefore, in spite of the long re-insemination interval, cows receiving 3TAI had improved reproductive performance than those receiving 1TAI and was attributed to the 10% increased proportion of pregnant cows in the first 42 days generated by the successful second TAI.

The results of these two studies indicate that TAI despite long re-insemination intervals either did not compromise or enhanced reproductive performance when compared to NS proving to be a successful alternative to eliminate the issues with estrus detection and the disadvantages of NS.

**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. The greatest impacts on net returns were obtained when TAI was used during summer compared to winter. This finding was attributed to lower estrus 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 estrus detection.

A TAI program using OvSynch was compared to AI at detected estrus in two large dairy herds differing in reproductive management. 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-day 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 estrus detection rates.

A direct comparison of the economics of TAI and NS was performed using as input the similar reproductive outcomes from the field trial\textsuperscript{18} that compared these two breeding programs.\textsuperscript{22} A herd budget including all costs and revenues was created taking into consideration all inputs relevant to determine the precise cost of each reproductive program. Net cost during the field study for the NS program was $100.49/cow per year and for the TAI program was $67.80/cow per year, unadjusted for differences in voluntary waiting period for first insemination (VWP) and pregnancy rates (PR). After inclusion of the differences in VWP and PR, the economic advantage of the TAI program was $9.73/cow per year. The costs per day per cow eligible for insemination were estimated at $1.45 for the NS program and $1.06 for the TAI program. Sensitivity analysis revealed that if the marginal feed cost increased to $5/hundredweight, which resembles the most common marginal feeding cost for most dairies, the advantage of TAI increased to $48.32/cow per year. If a marginal feed cost of $8/hundredweight was used then the profit from TAI in comparison to NS was more than two times greater ($109.58/cow per year). In addition, higher milk prices and greater genetic progress increased the advantage of TAI as well. Nonetheless, if dairy producers opt to use semen of $22 instead of $6, keeping the other input unchanged, the NS program had an economic advantage. If each NS bull present at lactating herd was replaced by an additional cow, the advantage of the TAI program was also greater ($60.81/cow per year). Setting the PR for both programs at 18% and the VWP at 80 d resulted in an advantage of $37.87/cow per year for the TAI program. In summary, this study showed that TAI was cheaper than NS in most of the scenarios evaluated and the reason for this advantage was dependent greatly on cost to feed bulls, milk price, genetic merit and the consideration of replacing or not bulls in the lactating pen by cows.

**Conclusion**

Timed AI and NS are two successful alternatives that dairy producers can use to eliminate estrus detection to breed lactating dairy cows. Both programs can achieve acceptable reproductive performance. It is critical to emphasize to dairy producers that dairy bulls can be dangerous and require very strict management to produce acceptable pregnancy rates. Timed AI is less expensive than NS and therefore it’s application is a better choice to eliminate problems of estrus detection in reproductive programs for lactating dairy cows.

**References**


**Figure.** Survival curves for proportion of non-pregnant cows by days postpartum for cows bred by natural service (NS) or timed AI (TAI) in the first 223 d postpartum. Median interval to pregnancy for NS and TAI groups was 111 d (95% confidence interval [CI]=104 to 125) and 116 d (95% CI=115 to 117), respectively. The rate of pregnancy in the 223 d postpartum was greater (P=0.05) for NS than TAI (adjusted hazard ratio=1.15; 95% CI=1.00 to 1.31).