STRATEGIES TO IMPROVE FERTILITY IN CATTLE: ARTIFICIAL INSEMINATION FOLLOWING ESTRUS VERSUS TIMED ARTIFICIAL INSEMINATION

Estrategias para mejorar la fertilidad en bovinos: Inseminación artificial después del estro versus inseminación artificial a tiempo fijo

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RESUMEN

Actualmente la inseminación artificial (AI) es la técnica más usada en el mundo para diseminar la genética superior y para mejorar la eficiencia reproductiva en hatos bovinos. No obstante, los reportes de diferentes partes del mundo indican una performance de baja tasa de preñez post inseminación, debido a errores en la detección de celo o una alta incidencia de anestros. En ganado lechero, el uso de AI seguido de una detección visual de celo es relativamente simple para su aplicación en un programa de manejo rutinario e intensivo (ordeños 2 a 3 veces por día), permitiendo un frecuente contacto con vacas en celo. Sin embargo, en ganado de carne, la implementación de programas de AI basados en detección de celo es difícil por el sistema de manejos de estos animales. Las vacas de carne son frecuentemente criadas en condiciones extensivas, con grandes distancias entre las zonas de pastoreo y el lugar de inseminación artificial, asimismo el número de operarios para el manejo es el mínimo y con funciones adicionales al manejo reproductivo. El programa de IA con celo natural requiere mínimo el manejo de dos períodos de observación de celo por día y la conducción de la vaca al lugar de inseminación dentro de las 12h siguientes a la detección de celo. El desarrollo de la inseminación a tiempo fijo en vacas a escala comercial permite programar un nuevo gran número de inseminaciones en pocos días, sin la necesidad de detección de estro. Asimismo, el uso de TAI en los días post parto temprano en ganado chero y carne reduce el intervalo parto concepción y consecuentemente el intervalo entre partos, lo cual causa un efecto dramático en el retorno económico. En ganado de carne la inseminación a tiempo fijo, tiene la ventaja de concentrar a las hembras en su mejor momento de fertilidad y estimulando la ciclicidad y sincronización de estros en vacas vacías. Otra de las ventajas, es que los partos son concentrados en el mejor periodo del año para generar un nacimiento exitoso con una potencialidad de desarrollo. La inseminación a tiempo fijo es una herramienta muy importante para mejorar la performance reproductiva en ganado lechero. Una adecuada incorporación de los programas de AI tienen el potencial de mejorar la fertilidad y consecuentemente incrementar la productividad.

Palabras clave: IATF estro, sincronización, bovino
ABSTRACT

Artificial insemination (AI) is currently the major biotechnique used worldwide to disseminate superior genetics and to improve reproductive efficiency in bovine herds. Conversely, reports from different parts of the world indicate low pregnancy rates in cattle submitted to AI, due to both mistakes in heat detection or a high incidence of anestrus. In dairy cattle, the use of AI following visual detection of estrus is relatively easier to be used because their routine of management is intense (milking two to three times a day), allowing a frequent contact with cows for estrus observation. However, for beef cattle, the implementation of AI programs based on estrus detection is harder to be used because of several management conditions. Beef cows are frequently raised extensively, with great walking distances between their pasture to the corral where the AI is performed, the number of employers designated for cattle management is reduced and they have several activities besides reproduction. Because of the necessity of at least two periods of estrus observation per day and the conduction of cattle to the corral around 12 h following estrus detection to be inseminated, the AI is somehow unfeasible in beef farms. The development of timed AI (TAI) enabled insemination of cows in commercial scale, because it allows the programmed AI of large number of cows in the same day without the need for estrus detection. Besides, the use of TAI in early postpartum dairy and beef females reduces the interval parturition-conception and, consequently the interval between parturitions, which has a dramatic effect on farm economic return. For beef cattle, TAI also brings the advantages of concentrating around half of the conceptions at the first days of the breeding season and stimulating cyclicity and a synchronous estrus return in cows that did not become pregnant at TAI. Thus, the calving season is also concentrate in the best periods of the year to generate offspring with greater weight and potential of development. TAI programs are currently important tools of reproductive management to improve reproductive performance of cattle. The adequate incorporation of these programs has the potential to enhance reproductive efficiency of livestock and consequently increase overall productivity of the farm.

Keywords: TAI, estrus, bovino, synchronization

INTRODUCCION

Artificial insemination (AI) is one of the most effective instruments available to cattle producers to improve productivity and profitability of cattle operation. The main advantages of using AI is the possibility to use sires of superior genetic merit, the capacity to mate specific sires to individual cows, the aggregation of increased genetics for replacement heifers, and the improvement of production traits in cattle operation. In beef cattle, the implementation of AI programs based on estrus detection is hampered by the frequent occurrence of postpartum anestrus and estrus detection failures (Williams et al., 1996; Baruselli et al., 2004). The estrus detection is impaired by technical and physiological problems, such as the large size of farms, the large number of animals per lot, the labor costs (Bó et al., 2007), the short period of estrus manifestation (around 10h) of Bos indicus cows (Randel, 1976; Galina and Arthur, 1990; Galina et al., 1996; Membrive, 2000; Rocha, 2000) and the high incidence of estrus at night (Pinheiro et al., 1998; Landaeta-Hernandez et al., 2002). The low estrus detection has been also reported for lactating dairy cows (Cordoba & Friek, 2001; Cordoba & Friek, 2002; Cavestany et al., 2007; Gutiérrez et al., 2009), Milk production is inversely proportional to estrus duration and reproductive performance of high producing dairy cows. Thus, estrus detection failure is a critical cause for poor reproductive efficiency of estrus detection-based reproductive programs (Senger, 1994).

Timed AI (TAI) programs allow insemination of cows regardless of cyclic status and eliminate the need for estrus detection, by exogenously controlling follicular and luteal function. These programs also afford an organized method to the use of AI, facilitating its use in beef and dairy herds (Baruselli, et al., 2004; Bó et al., 2007; Teixeira, 2010; Sá Filho et al., 2013). TAI programs for allow insemination of all cows at the beginning of the breeding season, increasing the proportion of pregnant cows early in the breeding season and increased overall proportion of cows pregnant the end of the breeding season (Cavestany et al., 2007; Gutiérrez et al., 2009; Teixeira, 2010; Herlihy et al., 2011; Sá Filho et al., 2013). However some questioning regarding the fertility of cows following TAI compared to estrus detection was raised and will be discussed above.

AI following estrus detection versus TAI in beef cattle

In pasture-based system, high pregnancy rates in the beginning of the breeding season are critical for herd profitability. Cows that conceive earlier in the breeding season calf earlier in the next calving season and consequently, have additional time for uterine regression before the next breeding season starts. This improves their chances to conceive again and reduces the risk of involuntary culling (Rhodes et al., 2003). Moreover, calves born early in the calving season have greater live weight at weaning than those born later in the calving
season, yielding additional income to the producer (Cutaia et al., 2003; Bó et al., 2005).

The high incidence of anestrus post-partum together with the difficulties for estrus detection in pasture-based systems make the use of TAI programs essential to concentrate conception early after post partum and guarantee satisfactory pregnancy rates at the end of the breeding season (reviewed by Baruselli et al. 2004; Sá Filho et al. 2013). Aiming to compare fertility after natural breeding and TAI programs and assure TAI is not prejudicial for conception outcomes, our research group designed two recent experiments (Sá Filho et al., 2013).

![Figure 1](image1.png)

Figure 1. Survival curves for proportion of non-pregnant cows by days of breeding season (BS) for different breeding strategies during a 90-d breeding season. TAI+NS (n=150): timed AI on Day 11 of the BS, followed by natural service (NS) until the end of the BS; TAI+ED+NS (n=148): TAI on Day 11, then estrus detection (ED) twice daily, with AI 12h after ED until Day 45 of the BS, followed by NS until the end of BS; ED+NS (n=147): AI 12h after ED during the first 45 d of the BS, followed by NS until the end of BS; NS (n=149): cows were bred by NS throughout the BS. Adapted from Sá Filho et al., 2013.

In the first study, we compared reproductive performance of Nelore cows subjected to four different reproductive programs in a 90-d breeding season: 1) only natural service (NS, n = 149), 2) AI after estrus detection for the first 45-d of the breeding season followed by NS (ED+NS, n = 147), 3) TAI followed by estrus detection + AI until 45-d of the breeding season and then NS (TAI+ED+NS, n = 148), and 4) TAI followed by NS (TAI+NS, n = 150). Time to pregnancy was reduced (P < 0.001) for TAI+NS and TAI+ED+NS (median days to pregnancy = 11 days) compared with ED+NS and NS cows (Figure 1). Moreover, greater (P = 0.001) proportion of cows was pregnant at 45 days of the BS when they were subjected to TAI (TAI+NS = 75.3%a, and TAI+ED+NS = 63.5%b) compared to cows from NS [(23.3%c) or ED+NS (44.3%d). Breeding by TAI (TAI+NS = 92.7%a; TAI+ED+NS = 91.9% a) also resulted greater (P < 0.01) proportion of cows pregnant at the end of the BS than cows not bred by TAI (ED+NS = 85.0% b; NS = 83.2% b).

In a subsequent study (Sá Filho et al., 2013), we compared the use of natural service (NS) alone during the entire breeding season with the used of TAI at onset of the breeding season followed by natural service (TAI+NS). A total of 507 postpartum beef cows Nelore and crossbred Nelore x Angus) were used. The use of TAI resulted in 52.4% P/AI. Similarly to the previous study, TAI cows had higher pregnancy rate at the first 45 d of the breeding season than those only exposed to natural bull mating (63.5% vs 46.3%, P = 0.001; Table 1 and Figure 2). However, similar pregnancy rates between groups were found at the end of the breeding season (Figure 2).

In this same study, when parity was evaluated, primiparous cows had lower P/AI following TAI and lower cumulative pregnancy rate during and at the end of the breeding season (Table 1). Indeed primiparous beef cows raised in pasture-based systems usually show prolonged periods of postpartum anestrus (Wiltbank, 1970) and reduced P/AI to TAI programs compared with multiparous cows (Sá Filho et al., 2009).

![Figure 2](image2.png)

Figure 2. Survival curves for proportion of non-pregnant cows by days of breeding season (BS) for postpartum beef cows bred by natural service (NS; dashed line; n=255) during a 90-d breeding season or by timed AI (TAI) at beginning of the BS followed by NS (TAI+NS; solid line; n=252). Median interval to pregnancy for NS and TAI groups was 55 d and 11 d (adjusted hazard ratio, 1.64; 95% confidence interval, 1.34–2.01), respectively. Adapted from Sá Filho et al., 2013.
Table 1. Reproductive performance of postpartum beef cows bred by natural service (NS) or timed artificial insemination (TAI) followed NS. Adapted from Sá Filho et al., 2013.

| Item         | N  | P/AI, % (N) | 45 days, % (N) | End, % (N) |
|--------------|----|-------------|----------------|------------|
| Breeding strategy |    |             |                |            |
| NS           | 255| -           | 46.3 (118)     | 71.0 (181) |
| TAI+NS       | 252| 52.4 (132)  | 63.5 (160)     | 77.0 (194) |
| NS           | 7  | 0.001       | 0.31           |            |
| Parity       |    |             |                |            |
| Primiparous  | 250| 41.3 (121)  | 36.8 (92)      | 58.0 (145) |
| Multiparous  | 257| 61.8 (131)  | 72.4 (186)     | 87.6 (225) |
| Breed        |    |             |                |            |
| Nelore       | 302| 45.0 (151)  | 46.4 (140)     | 62.5 (197) |
| Crossbred    | 205| 62.4 (101)  | 67.3 (138)     | 84.4 (173) |
| P            | 0.007| 0.03         | 0.05           |            |
| BCS          |    |             |                |            |
| Low (<3)     | 244| 40.5 (121)  | 38.9 (95)      | 58.6 (143) |
| Medium (≥3)  | 263| 62.0 (131)  | 69.6 (183)     | 86.3 (227) |
| P            | <0.001| 0.005        | 0.005          |            |

As for body condition score (BCS), it was also shown that assuring a good nutritional status at parturition (BCS ≥ 3.0; scale 1 to 5) is an important strategy to optimize the postpartum conception rate of beef cows, regardless of reproductive management (natural mating or TAI followed by natural mating; Table 1). Similar results were observed for postpartum Zebu cows previously by Ayres et al. (2014). Finally, it was also observed (Sá Filho et al., 2013) differences in conception for Bos indicus pure breed and crossbred Bos indicus × Bos taurus cows, regardless of reproductive program (Table 1).

Therefore, it is important to be aware of several particularities inherent to breed, parity, and nutritional status strategies that can affect the efficiency of reproductive programs. However, despite of these differences, TAI seems to be a strategic tool to anticipate conception early postpartum and to improve pregnancy outcomes at the end of the breeding season, without any lack of fertility compared to estrus detection programs.

AI following estrus detection versus TAI in dairy cattle

Although dairy cows are managed daily, allowing frequent observation of estrus, the main limiting factors for the massive use of AI are still the failures and difficulties to perform efficient estrus detection. Even in well-organized farms the rate of estrus detection barely achieves 50% (Van Eerdenburg et al., 2002), which in turn result in few number of AI (50% service rate).

Several studies were already performed aiming to evaluate the efficacy of the TAI protocols as a tool to improve reproductive management of dairy cows (Cordoba & Fricke, 2002; Cavestany et al., 2007; Gutiérrez et al., 2009; Lima et al., 2009; Bisinotto & Santos, 2010; Teixeira et al., 2010; Herlihy et al., 2011; Ribeiro et al., 2011; Rodrigues et al., 2011). Also, the concern of how TAI may affect fertility was investigated. In this context, similar P/AI has been found for cows breed after estrus detection or following TAI (Santos et al., 2009; Teixeira et al., 2010; Wiltbank et al., 2011). Furthermore, TAI protocols have the great advantage of anticipating the first service and conception postpartum, increasing the proportion of cows establishing pregnancy sooner after the voluntary waiting period (Cavestany et al., 2007; Gutiérrez et al., 2009; Teixeira, 2010; Herlihy et al., 2011).

In Brazil, the impact of TAI on the first day after the voluntary waiting period on reproductive performance of high-producing Holstein cows was compared to the use of Al after estrus detection (Teixeira, 2010; Table 1). For that, cows were subjected to Al following estrus detection during 150 days in milk (DIM) or first service with TAI followed by estrus detection and Al. Similar (P = 0.55) P/AI was obtained for cows receiving the first service following TAI or after estrus detection (Table 2). The second service was related to Al after the detection of estrus return from TAI cows vs estrus detection + Al cows. The second service P/AI was also similar (P = 0.92) between groups (Table 2).
Table 2. Pregnancy per AI (P/AI) 30 and 60 days after artificial insemination (AI) after estrus detection or timed AI (TAI) and pregnancy loss between 30 and 60 days after AI for the first and second services of Holstein cows; intervals calving – insemination, first – second AI, and calving – conception; service rate, and cumulative pregnancy rate at 150 days in milk (DIM). Adapted from Teixeira et al., 2010.

| Service                | Estrus detection + AI | TAI | P value |
|------------------------|-----------------------|-----|---------|
| **1st AI**             |                       |     |         |
| P/AI 30 d (%)          | 26.8 (125/467)        | 25.5 (126/495) | 0.55    |
| P/AI 60 d (%)          | 21.2 (99/467)         | 17.8 (88/495) | 0.13    |
| Pregnancy loss (%)     | 20.8 (26/125)         | 30.2 (38/126) | 0.09    |
| Interval calving - 1st AI (d) | 78.3 ± 0.9 | 60.6 ± 0.1 | 0.0001  |
| **2nd AI**             |                       |     |         |
| P/AI 30 d (%)          | 26.2 (74/283)         | 26.2 (90/344) | 0.92    |
| P/AI 60 d (%)          | 21.6 (61/283)         | 20.9 (72/344) | 0.89    |
| Pregnancy loss (%)     | 17.6 (13/74)          | 20.0 (18/90) | 0.73    |
| Interval calving - 2nd AI (d) | 105.1 ± 1.2 | 96.2 ± 0.9 | 0.001   |
| Service rate (57-78 DIM; %) | 41.4 (203/490) | 100.0 (203/490) | 0.001   |
| Interval 1st- 2nd AI (d) | 31.9 ± 0.85 | 37.6 ± 1.0 | 0.001   |
| Interval calving - conception | 94.6 ± 1.8 | 87.4 ± 1.8 | 0.005   |
| Pregnancy rate 150 DIM (%) | 41.8 (205/490) | 41.8 (207/495) | 0.99    |

Figure 2. Survival curves for proportion of non-pregnant cows by Days in milk for high-producing Holstein cows bred by artificial insemination after estrus detection (Estrus detection + AI; dashed line; n = 467) or by timed AI followed by AI after estrus detection (TAI followed by estrus detection + AI; solid line; n = 495) during 150 days post partum. Adapted from Teixeira et al., 2010.
However, shorter intervals from calving to first AI ($P = 0.001$), from calving to second AI ($P = 0.001$), from first and second AI ($P = 0.001$) and from calving to conception ($P = 0.005$) were observed in cows receiving one TAI after the voluntary waiting period followed by observation of estrus return and AI compared to AI after estrus detection during 150 days post partum (Table 2). The cumulative pregnancy rate after 150 DIM was similar among TAI cows and those inseminated only after visual estrus detection (Table 1).

Thus, TAI allowed the premature conception after the voluntary waiting period of high-producing Holstein cows, without reducing the conception rate after AI. Is also brings the advantage of increasing the first service rate post-partum from less than 50% to 100%, concentrating a greater number of pregnancies after the first post-partum insemination (Figure 2).

**CONCLUSIONES**

The TAI emerged as a crucial reproductive tool to improve beef and dairy herds’ reproduction efficiency and to accelerate herds’ genetic gain. It allows the anticipation of conception early after postpartum, diminishing the interval partum – conception and, consequently, the interval between two subsequent parturitions for close to 12 months for beef cattle and 13 months for dairy. The main results for beef herds are the production of more calves (one calf per cow per year), the improvement of the quality of calves (massive use of programmed AI), the reduction of involuntary culling at the end of the breeding season, and the availability of more genetically superior heifers for replacement of culled females. For dairy farms, TAI brings as advantage, the increase of milk production by shortening the interval between parturition (closer subsequent peak lactations) with high production of genetically superior heifers to start the reproductive programs. Moreover, TAI is secure for fertility, resulting in similar P/AI than females that underwent AI after estrus observation. However, TAI potentially increases service rates to 100%, and thus pregnancy rates, improving farms’ profitability.

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