R. Bras. Zootec., 49:e20190057, 2020
https://doi.org/10.37496/rbz4920190057

Reproduction
Full-length research article

Revista Brasileira de Zootecnia

*Brazilian Journal of Animal Science*
e-ISSN 1806-9290
www.rbz.org.br

# Weaning weight and optimization of reproductive efficiency in Nellore females subjected to timed artificial insemination

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**Received:** March 17, 2020
**Accepted:** July 19, 2020

**How to cite:** Ferreira, J. E.; Mello, M. R. B.; Silva, O. R.; Silenciato, L. N.; Couto, S. R. B. and Mello, R. R. C. 2020. Weaning weight and optimization of reproductive efficiency in Nellore females subjected to timed artificial insemination. Revista Brasileira de Zootecnia 49:e20190057.
https://doi.org/10.37496/rbz4920190057



**ABSTRACT** - The objective of this study was to evaluate the effect of timed artificial insemination (TAI) on pregnancy rates, reproductive efficiency, and mean weaning weight of calves at the end of breeding season in Nellore females. In this work, 744 Nellore females were divided into two groups: in group I (n = 396), the females were subjected to natural service during the breeding season, which lasts for 180 days. In group II (n = 348), a hormonal protocol was performed for synchronization of ovulation, and the females were subjected to TAI. Afterwards, these latter females were then serviced by a cleanup bull until the end of the breeding season. The group II obtained a higher pregnancy rate as well as higher reproductive efficiency compared with group I. The weaning weight of group II calves was greater than that of group I. The use of TAI combined with cleanup bulls enables higher pregnancy rates and a better reproductive efficiency in relation to the use of only natural service. In addition, weaning calves born from TAI are heavier than calves born from natural service.

**Keywords:** genetic improvement, reproductive management, weaning weight

## 1. Introduction

The use of artificial insemination (AI) arguably promotes a gain in the breeding herd, but it often ends up being hampered by labor-related issues and the detection of estrus females, especially in extensive beef cattle breeding systems. Timed artificial insemination (TAI) is a tool to assist the use of AI, facilitating handling and discarding the need to detect estrus. Moreover, the use of this biotechnology is important in decision-making in terms of financial return and reproductive efficiency of the herd.

The study by Pinheiro et al. (1998) demonstrated that in *Bos indicus* cows, 53.8% of estrus begin during the night, and 30.7% begin and end during the night. These particularities of the Zebu female reproductive system make it difficult to detect estrus as the management of these animals normally occurs in the daytime, thus justifying the use of tools such as TAI to improve reproductive efficiency in these herds.

According to Ferraz et al. (2012), about 80% of the herds in Brazil consist of the zebu species (*Bos taurus indicus*), which are mostly managed under extensive grazing systems, a fact that makes it difficult to detect estrus. Additionally, estrus in Zebu cows has shown to be of low intensity and short duration, making its detection even more difficult (Ramírez-Iglesia et al., 2014).

Thus, the vast majority of national herds use natural breeding as the main reproductive strategy, with around 85 to 90% of females undergoing this procedure. This extensive use is related to the fact that it is the simplest strategy, has the lowest cost, and is traditional (Araújo et al., 2012). However, the

proper use of AI associated with calving intervals of about 12 months is a growing need in current herd husbandry. Furthermore, the development of effective handling and management of reproductive procedures during the breeding season in beef cows becomes of great importance.

Current livestock systems require maximum reproductive and productive efficiency to provide a good economic return and still meet the growing demand for food for the world population. The high production levels associated with high reproductive efficiency should be the goals of technicians and producers to achieve higher productivity and a satisfactory cost-effective activity. Thus, optimization of manpower and maintenance of reproductive efficiency are the key factors that contribute to improve the production performance and profitability of commercial herds.

The major challenge nowadays is to get good reproductive efficiency when breeding beef cattle. Thus, to improve the productivity of the national herd, reproductive biotechnologies, such as TAI, have been developed to facilitate management, reduce manpower, and focus the activities, mainly in beef cattle, on the breeding season (Baruselli et al., 2017).

Timed artificial insemination is the main technological management system used in Brazil. This up-to-date technological management system intensifies activities at the beginning of the breeding season, concentrates work on predetermined days, concentrates deliveries in the calving season, and facilitates handling of the offspring; furthermore, it helps form homogeneous lots of animals for the fattening phase and replacement of heifers (Palhano et al., 2012).

Therefore, the objectives of this study were to evaluate the TAI effect on pregnancy rates and reproductive efficiency of Nellore females in the breeding season and to compare the average weight of calves at weaning following TAI or natural service (NS).

## 2. Material and Methods

The present experiment was approved by the institutional Committee of Ethics in the Use of Animals (case no. 5914230217). This experiment was held near the city of Valença, RJ, Brazil (22°14'44" S, 43°42'01" W, and 560 m above sea level), from November 2013 to June 2014.

The bulls were removed from the herd in August 2013 and returned in November of the same year, when the 2013/2014 breeding season began. The farm activities are breeding, rearing, and fattening Nellore beef cattle.

We used 744 Nellore females (cows and heifers) with ages ranging from three to eight years old. The selected animals had a body condition score (BCS) ranging from 2 to 3, and they were free of diseases that might affect reproduction, such as brucellosis, infectious bovine rhinotracheitis (IBR), bovine viral diarrhea (BVD), leptospirosis, campylobacteriosis, and genital bovine trichomoniasis. Although the animals did not show any change in the clinical and gynecological examinations to call attention to these and other diseases that affect reproduction, vaginal mucosa cells were collected for laboratory tests, and serological exams were carried out to confirm the absence of these diseases.

The Nellore cows were divided into two treatments; the lactation condition (lactating and non-lactating) and the BCS were similar in both groups. The treatments were as follows: group I (n = 396) and group II (n = 348). The females of group I were subjected to NS throughout the breeding season, which lasted 180 days and began in November 2013 and ended in April 2014. The females in group II underwent TAI and subsequent bull cleanup. Prior to the synchronization of ovulation, they were subjected to gynecological screening by rectal palpation and ultrasound examinations (Mindray DP 2200-Vet, rectal probe of 5 MHz). The pregnant females as well as those that presented congenital or acquired genital tract diseases (vaginitis, follicular cyst, tortuous, and full cervix or unilateral ovarian hypoplasia) that could affect fertility were excluded from the experiment. Furthermore, for the animals in the TAI program, special care was taken to separate cyclic animals (with corpus luteum) and with

good body condition from the anestrus animals and a poor BCS (less than 3 on a scale of 1-5), for the use of a more appropriate hormone protocol.

The protocol used was based on a combination of estradiol and progesterone. At a random stage of the estrous cycle, the females received an intravaginal device containing 1 g of progestin (P4) and 2 mg estradiol benzoate intramuscularly (IM), which was then considered day 0 (d0). At d8 females received 150 μg cloprostenol (IM) and 1 mg estradiol cypionate (IM), and the P4 device was removed. The animals in anestrus and/or low body condition in the gynecological screening also received 300 IU of equine chorionic gonadotropin (eCG).

On d10, all females were subjected to TAI. After 15 days, all females were placed with bull for cleanup through to the end of the breeding season. There was a ratio of one bull for 30 cows. The diagnosis of pregnancy by rectal palpation was carried out with the aid of transrectal ultrasonography 60 days after TAI (to differentiate the TAI pregnancies from the natural breeding pregnancies) and at the end of the breeding season (to assess potential pregnancy loss). All bulls used in this experiment underwent the bull breeding soundness evaluation 60 days before the start of the breeding season. In terms of nutritional management, all animals were kept during the experiment on pastures with *Brachiaria decumbens* and mineral supplementation, and water was *ad libitum*.

To evaluate the average weaning weight of calves, from the NS and TAI, a conventional electronic scale for cattle was used. The weight of the calves was recorded in kilograms at the time of weaning and adjusted to the weight at 210 days (seven months) after birth of each calf, when they were separated from their mother (traditional weaning). As this was the first year of the breeding season at this property, the calves from NS were not homogeneous and not all of them were weaned at seven months. Therefore, weaning was considered to complete in a range of five to nine months after birth. The weight of the calves was adjusted to 210 days according to the average daily weight gain of each calf.

Statistical analysis was performed using the chi-square test with a significance level of 1% ($P<0.01$). The following reproductive parameters were analyzed: pregnancy rate (number of pregnant animals compared with the total number of breeding females at the end of the breeding season) and reproductive efficiency (number of animals born in relation to the number of females of reproductive age of each group). An ANOVA test with a significance level of 1% ($P<0.01$) was used to determine the average weaning weight of calves in each group.

A completely randomized design was used with two groups (group I and group II) with, respectively, 396 and 348 repetitions for group. The data related to reproductive parameters were subjected to tests that use the chi-square distribution as a probabilistic structure and, in these cases, the mathematical model used was:

$$\chi^2 = \sum_{i=1}^{l} \sum_{j=1}^{c} \frac{(A_{ij} - E_{ij})^2}{E_{ij}}$$

in which $A_{ij}$ = actual frequency in the $i$-th row, $j$-th column; $E_{ij}$ = expected frequency on the $i$-th row, $j$-th column; $l$ = number of lines; and $c$ = number of columns.

## 3. Results

The pregnancy rate was lower in group I (56.1%) than in group II (77.2%) (Table 1), with a statistical difference ($P = 0.0009$).

Another important aspect analyzed in this study was the weight of the calves from the TAI and the NS at the time of weaning (at 210 days): the average weight of the calves from the TAI was significantly higher than the weight of the calves from the NS ($P = 0.0088$) (Table 2).

The reproductive efficiency of this study was 54.8% in group I and 75.5% in group II and was statistically different ($P = 0.0009$).

**Table 1 -** Pregnancy rate and reproductive efficiency of Nelore females subjected to natural service (NS) or timed artificial insemination (TAI) + NS

| Treatment | NS | TAI + NS | P-value |
|---|---|---|---|
| Number of animals | 396 | 347 | - |
| Pregnancy rate (%) | 56.1b | 77.2a | 0.0009 |
| Reproductive efficiency (%) | 54.79b | 75.5a | 0.0009 |

Means followed by different letters in the same row are significantly different (P<0.01).

**Table 2 -** Total number of weaned animals, average weight at weaning, and standard deviation of calves from the natural service (NS) and timed artificial insemination (TAI)

| Treatment | NS | TAI | P-value |
|---|---|---|---|
| Number of animals | 161 | 109 | - |
| Average weight at weaning | 160.38b | 167.97a | 0.0088 |
| Standard deviation | 21.72 | 25.04 | - |

Means followed by different letters in the same row are significantly different (P<0.01).

## 4. Discussion

The females that underwent TAI and subsequently placed with the bull had a better result, more pregnancies when compared with females that were with the bull the whole breeding season and not subjected to synchronization and insemination. This difference probably occurred as a result of the previous synchronization to the TAI that induced the cyclicity of the females in anestrus, thus enabling pregnancy through artificial insemination. The hormonal protocol probably promoted cyclicity, which resulted in the return of synchronized estrus even in the females that did not become pregnant after TAI, and thus made pregnancy feasible in these females by NS.

The results of reproductive efficiency in this study corroborate the results obtained by Sá Filho et al. (2015), who evaluated the effect of TAI reproductive efficiency of lactating Nellore cows and concluded that the use of this biotechnology significantly increased the proportion of pregnant cows at the start of the breeding season when compared with animals that were only with the bull. Our results are also in accordance with the results presented by Ferreira et al. (2018), who also showed that TAI improved reproductive performance of primiparous and acyclic Nellore cows compared with the use of only NS.

However, the findings of the present study disagree with the results found by Gutierrez et al. (2014), who observed no differences in pregnancy rate and reproductive efficiency of Angus heifers subjected to TAI + NS or NS only. The differences compared with the results of this study can be explained by such factors as the category and breed of animals used (Angus heifers versus Nellore cows and heifers). In addition, the protocols used for hormonal synchronization of ovulation are distinct; in the present study, the base with estrogens and progestins and eCG were added at the time of device removal (for anestrous animals and animals with low BCS (<3)), while in the work by Gutierrez et al. (2014), the "pre-synch" progestin protocol was used.

The results of this study also disagree with those of Gottschall et al. (2012), who showed no significant difference in reproductive efficiency of beef heifers under different mating systems (TAI + NS and NS only). This can be explained by the difference in breed (Aberdeen Angus) and especially the hormonal protocol to which the animals were subjected (without the use of eCG).

More recently, Baruselli et al. (2018) compared the performance of different reproductive programs using NS, estrus synchronization treatment before NS, AI following estrus detection, and TAI in beef herds. Through the review, it was possible to conclude that even with different programs, these technologies can contribute to improving the production efficiency, and consequently, the livestock profitability.

The reproductive efficiency seeks to measure the efficiency of a herd with regard to reproduction and can be quantified by the direct relationship between the number of calves born in a one-year period and the number of breeding females. Females with low reproductive efficiency become a financial burden as they do not give birth and wean a calf every year and, therefore, should be discarded. A balanced diet is one of the factors that has a great impact on the reproductive efficiency of a breeding herd, because animals with low body condition and low weight do not go into estrus, ovulate, or become pregnant.

Reproductive efficiency is associated to various forms of management such as a short breeding season and lactation period, which is when nutritional requirements are greater, and therefore should coincide with when there is an increased supply of food. Thus, the remaining management activities can be scheduled at appropriate times throughout the year to attain maximum efficiency.

The difference between mean weights of the calves from the TAI and NS can be attributed to genetic improvement provided by artificial insemination; the AI adds important features to the product generated, for example, conformation, angulation, pasture weight gain, carcass quality, and weaning weight, the latter being one of the most desirable benefits for beef cattle. And even using bulls of the same breed (Nellore) in both TAI and NS, calves are, on average, 7.59 kg heavier than calves from the NS, which obviously adds value to this product.

These results are in agreement with those by Nogueira (2017), who found a significant difference in weaning weight of TAI calves that were greater than the average weaning weight of NS calves. The results of this study also corroborate with Lamb and Mercadante (2016), who observed a higher weaning weight ($P<0.05$) in the TAI animals than in the NS animals.

The use of TAI in this study also provided greater financial returns due to the value added to the product at the time of weaning (on average, the TAI calves were 7.59 kg heavier than the NS calves). Considering R$ 12.00 as the per kilo price of a calf in the Valencia region, RJ, each TAI calf represented R$ 91.08 more compared with the calf from only bull breeding. This higher value of the TAI calf is enough to cover all the extra investments carried out relating to the mother of the calf. It is important to remember that in addition to higher weaning weight, there is a higher pregnancy rate and still a better reproductive efficiency in females that underwent the TAI program.

The results of the financial returns of this study are consistent with results found by Lamb and Mercadante (2016), who also obtained higher returns with TAI compared with NS because of the increasing number of products, improvements in reproductive efficiency of the herd, and even the added value to the product from a TAI in a herd of beef cattle.

## 5. Conclusions

The use of timed artificial insemination, with associated bull cleanups, increases the pregnancy rates and, consequently, the reproductive efficiency of Nellore females compared with the use of only natural breeding. Nellore calves weaned from the timed artificial insemination system weigh more than Nellore calves conceived by natural service.

## Conflict of Interest

The authors declare no conflict of interest.

## Author Contributions

Conceptualization: J.E. Ferreira, M.R.B. Mello, O.R. Silva and L.N. Silenciato. Data curation: J.E. Ferreira, M.R.B. Mello, O.R. Silva and L.N. Silenciato. Formal analysis: J.E. Ferreira, M.R.B. Mello and L.N. Silenciato. Funding acquisition: J.E. Ferreira, M.R.B. Mello, L.N. Silenciato, S.R.B. Couto and R.R.C. Mello. Investigation: J.E. Ferreira, M.R.B. Mello, O.R. Silva and L.N. Silenciato. Methodology: J.E. Ferreira, M.R.B. Mello, O.R. Silva and L.N. Silenciato. Project administration: J.E. Ferreira, M.R.B. Mello, O.R. Silva, L.N.

Silenciato and S.R.B. Couto. Resources: M.R.B. Mello and O.R. Silva. Software: M.R.B. Mello and O.R. Silva. Supervision: J.E. Ferreira, M.R.B. Mello and O.R. Silva. Validation: J.E. Ferreira, M.R.B. Mello and O.R. Silva. Visualization: J.E. Ferreira, M.R.B. Mello and O.R. Silva. Writing-original draft: J.E. Ferreira, M.R.B. Mello, O.R. Silva, L.N. Silenciato and R.R.C. Mello. Writing-review & editing: J.E. Ferreira, M.R.B. Mello, O.R. Silva, L.N. Silenciato and R.R.C. Mello.

## Acknowledgments

The authors would like to thank the Fazenda Santana, for making the experimental area available. We would also like to thank Felipe Zumkeller Garcia, zootechnician, responsible for the experimental area. This work was conducted during a scholarship supported and financed by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) – a Brazilian Federal Agency for Support and Evaluation of Graduate Education within the Ministry of Education of Brazil.

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