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HORMONAL PROTOCOLS AND REPRODUCTIVE EFFICIENCY IN FIXED-TIME ARTIFICIAL INSEMINATION (FTAI) IN ANIMALS

PROTOCOLOS HORMONAIS E EFICIÊNCIA REPRODUTIVA NA INSEMINAÇÃO ARTIFICIAL EM TEMPO FIXO (IATF) DE ANIMAIS

PROTOCOLOS HORMONALES Y EFICIENCIA REPRODUCTIVA EN LA INSEMINACIÓN ARTIFICIAL A TIEMPO FIJO (IATF) EN ANIMALES

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ABSTRACT

Fixed-Time Artificial Insemination (FTAI) represents one of the main biotechnologies applied to bovine reproduction, contributing to genetic improvement, increased productive efficiency, and optimization of reproductive herd management. The present study aimed to review the main hormonal protocols used in FTAI and the factors influencing reproductive efficiency in cattle. This is a narrative literature review developed from scientific articles published over the last fifteen years and indexed in the PubMed database. The results demonstrate that hormonal protocols based on GnRH, estradiol, progesterone, and equine chorionic gonadotropin (eCG) promote ovulation synchronization and improve pregnancy rates, especially when associated with proper animal management. Furthermore, factors such as body condition score, heat stress, nutritional status, herd health, and technical training of professionals directly influence reproductive outcomes. Recent studies also highlight the potential use of molecular biomarkers as auxiliary tools for early pregnancy assessment. It is concluded that the association between efficient hormonal protocols, appropriate sanitary and nutritional management, and biotechnological advances is essential to maximize reproductive performance in FTAI.

Keywords: Cattle. Animal Reproduction. Hormonal Protocols. Fertility. Reproductive Biotechnology. Fixed-Time Artificial Insemination.

RESUMO

A Inseminação Artificial em Tempo Fixo (IATF) representa uma das principais biotecnologias aplicadas à reprodução bovina, contribuindo para o melhoramento genético, aumento da eficiência produtiva e otimização do manejo reprodutivo dos rebanhos. O presente estudo teve como objetivo revisar os principais protocolos hormonais utilizados na IATF e os fatores que influenciam a eficiência reprodutiva em bovinos. Trata-se de uma revisão bibliográfica narrativa, desenvolvida a partir de artigos científicos publicados nos últimos quinze anos e indexados na base de dados PubMed.

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Os resultados demonstram que os protocolos hormonais baseados em GnRH, estradiol, progesterona e gonadotrofina coriônica equina (eCG) promovem a sincronização da ovulação e melhoram as taxas de prenhez, especialmente quando associados ao manejo adequado dos animais. Além disso, fatores como escore de condição corporal, estresse térmico, estado nutricional, sanidade do rebanho e capacitação técnica dos profissionais influenciam diretamente nos resultados reprodutivos. Estudos recentes também destacam o potencial uso de biomarcadores moleculares como ferramentas auxiliares na avaliação precoce da prenhez. Conclui-se que a associação entre protocolos hormonais eficientes, manejo sanitário e nutricional adequado e avanços biotecnológicos é essencial para maximizar o desempenho reprodutivo na IATF.

Palavras-chave: Bovinos. Reprodução Animal. Protocolos Hormonais. Fertilidade. Biotecnologia Reprodutiva. Inseminação Artificial em Tempo Fixo.

RESUMEN

La Inseminación Artificial a Tiempo Fijo (IATF) representa una de las principales biotecnologías aplicadas a la reproducción bovina, contribuyendo al mejoramiento genético, al aumento de la eficiencia productiva y a la optimización del manejo reproductivo de los rebaños. El presente estudio tuvo como objetivo revisar los principales protocolos hormonales utilizados en la IATF y los factores que influyen en la eficiencia reproductiva en bovinos. Se trata de una revisión bibliográfica narrativa, desarrollada a partir de artículos científicos publicados en los últimos quince años e indexados en la base de datos PubMed. Los resultados demuestran que los protocolos hormonales basados en GnRH, estradiol, progesterona y gonadotropina coriónica equina (eCG) promueven la sincronización de la ovulación y mejoran las tasas de preñez, especialmente cuando se asocian con un manejo adecuado de los animales. Además, factores como la condición corporal, el estrés térmico, el estado nutricional, la sanidad del rebaño y la capacitación técnica de los profesionales influyen directamente en los resultados reproductivos. Estudios recientes también destacan el potencial uso de biomarcadores moleculares como herramientas auxiliares en la evaluación temprana de la preñez. Se concluye que la asociación entre protocolos hormonales eficientes, un manejo sanitario y nutricional adecuado y los avances biotecnológicos es esencial para maximizar el desempeño reproductivo en la IATF.

Palabras clave: Bovinos. Reproducción Animal. Protocolos Hormonales. Fertilidad. Biotecnología Reproductiva. Inseminación Artificial a Tiempo Fijo.

1 INTRODUCTION

The implementation of artificial insemination (AI) in cattle aims to promote sustained genetic progress in herds, being one of the oldest and most effective reproductive biotechnologies (Bó et al., 2014; Dalton et al., 2021). However, the efficiency of conventional AI is often limited by factors such as inadequate nutrition, management failures, and the low detection rate of estrus (Bó et al., 2014; Sartori et al., 2023). In this context, the development of Fixed Time Artificial Insemination (TAI) protocols has revolutionized livestock farming, allowing the insemination of large groups of animals, including cows in postpartum anestrus, without the need for heat observation (Bó et al., 2014; Sartori et al., 2023).

FTAI protocols are based on pharmacological manipulation of the estrous cycle to synchronize follicular wave emergence, dominant follicle development, and ovulation (Bó et al., 2014; Sartori et al., 2023). There are two main approaches: GnRH-based protocols, widely used in North America and Europe, and estradiol and progesterone-based protocols, prevalent in South America (Bó et al., 2014; Sartori et al., 2023). The choice and adjustment of these protocols depend on genetic particularities (*Bos taurus* vs. *Bos indicus*), metabolic status, and hormonal environment, especially circulating progesterone concentrations (Sartori et al., 2023). The aim of this review is to analyze advances in hormonal protocols and factors that influence reproductive efficiency in TAI.

2 METHODOLOGY

The present study is characterized as a narrative literature review, developed with the objective of synthesizing and analyzing the most recent scientific evidence related to hormonal protocols and reproductive efficiency in animal FTAI. The search was carried out in the PubMed database, using the descriptors Insemination, Artificial and Cattle, combined through the Boolean operators AND and OR, according to the terminology of the Medical Subject Headings (MeSH). Articles published in the last fifteen years, available in full and written in Portuguese or English, that directly addressed the theme, were included. Studies that did not have a direct relationship with the central theme, duplicate publications, narrative reviews with low methodological rigor, and articles not indexed in the database used were excluded. The selection of studies was conducted in two stages: screening of titles and abstracts, followed by the evaluation of full texts to confirm relevance. The information extracted was organized in a descriptive way.

3 RESULTS AND DISCUSSION

3.1 FOLLICULAR DYNAMICS AND HORMONAL CONTROL

Synchronizing follicular wave emergence is the critical first step to the success of TAI. In estradiol-based protocols, the administration of estradiol benzoate associated with progesterone devices induces atresia of the follicles present and allows the emergence of a new wave at a predictable time (Bó et al., 2014; Sartori et al., 2023). In GnRH-based protocols, synchronization depends on the ovulation of the dominant follicle present at the beginning of treatment, which occurs in about 50% of dairy cows (Sartori et al., 2023).

The concentration of progesterone during follicular growth exerts different effects between beef and dairy cattle. In high-producing dairy cows, higher levels of progesterone are desirable to reduce the frequency of LH pulses, preventing follicle overdevelopment and improving oocyte quality (Sartori et al., 2023). In contrast, in beef cows, excessively high levels of progesterone can slow follicular growth, and prostaglandin administration is sometimes necessary at the beginning of the protocol to optimize the diameter of the ovulatory follicle (Sartori et al., 2023).

3.2 FACTORS AFFECTING FERTILITY IN FTAI

Reproductive efficiency is influenced by clinical and environmental variables. A recent finding indicates that rectal temperature at or shortly before FTAI is positively associated with pregnancy rates, on average for each 1ºC increase the odds of pregnancy increased 1.9 times with a confidence interval of 1.4 to 2.6, in both *Bos indicus* and *Bos taurus* cattle (Liles et al., 2022). Hyperthermia is common during estrus and can promote meiotic oocyte retake and alter components of follicular fluid that favor ovulation. (Liles et al., 2022). In addition, the body condition score (BCS) remains one of the main predictors of success, with cows in negative energy balance showing worse conception rates (Bó et al., 2014). Animals with higher BCS had higher conception and pregnancy rates, associated with the presence of a larger ovulatory follicle, higher ovulation rates and larger area of the corpus luteum at the beginning of diestrus. (Nishimura et al., 2018). In addition, an experimental study reiterated that cows with a body condition score of 5.0 had better gestation results when there was a breeding season combining fixed-time artificial insemination and natural mounting, calved and weaned more calves, older and with higher weaning weight, and produced more kg of weaned calf per cow in the breeding herd compared to cows with BCS <5.0. These results

were observed in cow herds with B. indicus in Brazil and B. taurus in the USA. (Cooke et al., 2021). Additionally, the increase in the dose of estradiol cypionate in the breeding season led to an increase in the pregnancy rate of a herd of Bos Indicus with a body condition score below 2.75. (Sales et al., 2023).

The use of equine chorionic gonadotropin (eCG) at the time of progesterone device removal is an effective strategy to increase follicular growth rate and subsequent corpus luteum function, especially in cows in postpartum anestrus (Bó et al., 2014; Sartori et al., 2023). On the other hand, the search for early pregnancy biomarkers, such as blood levels of miR-26a, showed that, although there are statistical variations, these miRNAs still do not offer diagnostic accuracy superior to traditional methods before 21 days after AI (Tzelos et al., 2023).

3.3 TECHNICAL EDUCATION AND TRAINING

Technical proficiency in semen handling and AI execution is critical to translating hormonal protocols into field results. Hands-on training programs for students and professionals are essential to ensure the correct deposition of semen in the uterine body and the maintenance of sperm viability during thawing (Dalton et al., 2021). Knowledge of reproductive anatomy and correct interpretation of synchronization tables are skills that reduce the variability of results between herds (Dalton et al., 2021).

4 CONCLUSION

The implementation of FTAI protocols, with the strategic use of hormones such as GnRH, estradiol, progesterone and eCG, is essential for the synchronization of ovulation, promoting genetic progress and increasing reproductive efficiency in cattle herds.

The success of FTAI lies not only in the choice of hormonal protocol, which must be adjusted to the follicular dynamics and metabolic status of the animal, but is also strongly influenced by extrinsic factors. BCS stands out as the main predictor of fertility, being essential to ensure higher conception rates and better productive performance. Environmental variables, such as rectal temperature at the time of FI, also show a positive association with pregnancy rates.

Additionally, the technical proficiency of the professionals involved, including the correct handling of semen and knowledge of reproductive anatomy, is critical to translate hormonal protocols into satisfactory results in the field. Future research, such as the study

of molecular biomarkers (e.g., miR-26a), continues to demonstrate potential to refine early diagnosis and reproductive management.

In short, maximizing reproductive performance in FTAI depends on an integrated approach that combines the optimization of hormonal protocols, rigorous sanitary and nutritional management, and the constant technical updating of professionals, capitalizing on advances in reproductive biotechnology.

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