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Energy-protein supplementation before and after parturition of Nellore primiparous cows in the Brazilian tropical savannah

Suplementação proteico-energética antes e após o parto para vacas primíparas Nelore na savana tropical brasileira

Suplementación de energía y proteína antes y después del parto de vacas primiparias Nellore en la sabana tropical brasileña

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Ipojucan de Goias Brasil
ORCID https://orcid.org/0000-0003-0050-8296
Universidade Federal de Goias, Brazil
E-mail: ipojucangoias@hotmail.com
André Coelho Naves
ORCID https://orcid.org/ 0000-0002-1457-4959
Universidade Federal de Goias, Brazil
E-mail: navesac68@gmail.com
Isabelle Matos Macedo
ORCID https://orcid.org/0000-0002-1204-1833
Universidade Federal de Goias, Brazil
E-mail: isa_belle258@hotmail.com
Rafaela Cavalcanti Teixeira
ORCID https://orcid.org/0000-0002-0422-0356
Universidade Federal de Goias, Brazil
E-mail: rafaela.cavalcanti@msn.com
Marco Antonio de Oliveira Viu
ORCID https://orcid.org/0000-0003-4926-1298
Universidade Federal de Jataí, Brazil
E-mail: marcoviu@gmail.br
Dymar Toledo Lopes
ORCID https://orcid.org/0000-0003-1378-5321
Universidade Federal de Jataí, Brazil
E-mail: dtl.ufg@gmail.com
Maria Lucia Gambarini
ORCID https://orcid.org/0000-0003-0517-7270
Universidade Federal de Goias, Brazil
E-mail: marialucia@ufg.br

Abstract
Reproduction is associated to the profitability of beef herds, which affects the level of productivity and is influenced by nutritional level. The objective of this study was to evaluate the effect of protein and energy supplementation, before and after parturition, on reproductive variables of Nellore primiparous cows extensively raised in the Brazilian tropical savannah. Eighty pregnant heifers with parturition estimated for a 45 d period during the dry season were randomly divided into four treatments: CONTROL, received a mineral salt and urea mixture pre and postpartum; PRE, protein-energy mixture from the 210th gestational day until parturition; POS, protein-energy mixture from parturition until 90 d afterwards; PREPOS, protein/energy mixture from the 210th gestational day until the 90th day after parturition. Number of days to complete uterine involution (UI) was 37.0 (CONTROL); 31.3 (PRE); 33.1 (POST) and 25.3 (PREPOST) with differences (P<0.05). Calving Interval (CI) was 370.4 (CONTROL), 369.5 (PRE); 365.9 (POST) and 343.7 (PREPOST) days, with differences (P<0.05). Pregnancy rate (PR) was 64.7%; 76.5%; 65.0%; and 55.0%, respectively, for CONTROL PRE, POS, PREPOS, without difference (p>0.05). In conclusion, energy-protein supplementation of Nellore primiparous cows raised in extensive systems under tropical conditions, before and after parturition, reduces days to uterine involution and calving interval.
Keywords: Reproductive efficiency; Pregnancy rate; Nutritional supplement.

Resumo
A reprodução está associada à rentabilidade do rebanho bovino, o que afeta o nível de produtividade e é influenciado pelo nível nutricional. O objetivo deste estudo foi avaliar o efeito da suplementação proteica e energética, antes e

depois do parto, sobre as variáveis reprodutivas das vacas primíparas Nelore criadas extensivamente na savana tropical brasileira. Oitenta novilhas gestantes com parto estimado para um período de 45 dias durante a estação seca foram divididas aleatoriamente em quatro tratamentos: CONTROLE, recebeu uma mistura de sal mineral e ureia pré e pós parto; PRE, mistura proteína-energia desde o 210º dia gestacional até ao parto; POS, mistura proteína-energia desde o parto até 90º dia após o parto; PREPOS, mistura proteína-energia desde o 210º dia gestacional até o 90º dia após o parto. O número de dias para completar a involução uterina (IU) foi 37,0 (CONTROLE); 31,3 (PRE); 33,1 (POST) e 25,3 (PREPOST) com diferenças ($p<0,05$). O Intervalo de parto (IC) foi de 370,4 (CONTROLE), 369,5 (PRE); 365,9 (POST) e 343,7 (PREPOST) dias, com diferenças ($p<0,05$). A taxa de prenhez (TP) foi de 64,7%; 76,5%; 65,0%; e 55,0%, respectivamente, para CONTROLE, PRE, POS, PREPOS, sem diferença ($p>0,05$). Em conclusão, a suplementação proteico-energética para vacas primíparas Nelore criadas em sistemas extensivos em condições tropicais, antes e depois do parto, reduz os dias para involução uterina e intervalo de partos.
Palavras chave: Eficiência reprodutiva; Taxa de prenhez; Suplementação nutricional.

Resumen
La reproducción está asociada a la rentabilidad de los rebaños vacunos, que afecta al nivel de productividad y está influenciada por el nivel nutricional. El objetivo de este estudio fue evaluar el efecto de la suplementación proteica y energética, antes y después del parto, sobre las variables reproductivas de vacas primíparas Nellore criadas extensivamente en la sabana tropical brasileña. Ochenta novillas preñadas con parto estimado para un período de 45 días durante la estación seca fueron divididas al azar en cuatro tratamientos: CONTROL, recibieron una mezcla de sales minerales y urea antes y después del parto; PRE, mezcla proteico-energética desde el 210º día de gestación hasta el parto; POS, mezcla proteico-energética desde el parto hasta 90 d después; PREPOS, mezcla proteico-energética desde el 210º día de gestación hasta el 90º día después del parto. El número de días para completar la involución uterina (UI) fue de 37,0 (CONTROL); 31,3 (PRE); 33,1 (POST) y 25,3 (PREPOST) con diferencias ($P<0,05$). El intervalo entre partos (IC) fue de 370,4 (CONTROL), 369,5 (PRE); 365,9 (POST) y 343,7 (PREPOST) días, con diferencias ($P<0,05$). La tasa de preñez (TR) fue de 64,7%; 76,5%; 65,0%; y 55,0%, respectivamente, para CONTROL PRE, POS, PREPOS, sin diferencias ($P> 0,05$). Em conclusion, a suplementación energético-proteica de vacas primíparas Nellore criadas en sistemas extensivos en condiciones tropicales, antes y después del parto, reduce los días de involución uterina y el intervalo entre partos.
Palabras clave: Eficiencia reproductiva; Tasa de preñez; Suplemento nutricional.

1. Introduction

In Brazil, 80% of commercial herds is compose by Nellore cattle (ACNB, 2019), handled under extensive conditions, with a breeding season during summer or the rainy season, from October until April, with the concentration of the reproductive programs from December until March, and calving season during the dry season, when pastures can poorly provide animal needs. Nellore is a Zebu cattle from India well adapted to adverse environment, high fertility, and good maternal instinct. One of the Brazilian regions with the highest cattle pasture-based production (about 48.5 million Ha) is located in the tropical savannah, also known as Cerrado biome or seasonal forest (Batalha, 2011).

Reproduction is associated to the profitability, which affects productivity and depends on nutritional, genetic, sanitary and efficient management factors. The prolonged postpartum anoestrus is the most important cause of low reproductive efficiency and can be affected by the inadequate nutrition during the pre and postpartum period. The economic return of nutritional investment for Nellore cattle reared in pasture could be similar between protein-energy and energy supplementation. During the period of lower availability of forage, it is necessary to supplement the cattle to meet the nutritional demand and correct nutrient deficiencies in the pastures, ensuring the producer's final profitability (Ziemniczak et al. 2020).

Low energy level during the final period of pregnancy leads to low conception rates (Diskin et al. 2016). For the primiparous cow the challenge is to meet growth, lactation and a new gestation needs, and they frequently fail to demonstrate fertile estrus during lactation (Nogueira et al., 2014). Because tropical grasses have nutritional limitations and constrains intake and digestibility, it is mandatory to implement an appropriate supplementation program in pasture-based beef cattle production systems. Nutritional supplementation with protein-energy mixtures for beef heifers reduces losses during pre and postpartum period and probably favors the reproductive efficiency (Souza et al., 2010), and the use of non-degradable protein shown to be efficient to increase the availability of follicle-stimulating hormone (FSH), favoring the follicular dynamics (Kane et al., 2004).

During gestation there is a gradual increase of nutritional requirements and a decrease in the ingestion due fetal growth. The improvement of the energy and protein level might increase the dry matter intake, can improve energy balance and calf weight at birth. Soon after calving, lactation increases the dam's nutritional requirements and cows experience a negative energy balance and consequent suppression of reproductive activity (Diskin et al. 2016). Probably nutritional restrictions during this period will cause disorders in the hypothalamic-pituitary-gonadal axis, due to changes in glycogenesis. Even for Nellore breed, which animals are adapted to the tropical environment, the primiparous cow still represents a restrictive situation for the production systems (Astessiano et al. 2013).

The hypothesis of this study was that a strategic protein-energy supplementation during pre and/or postpartum period would decrease days to complete uterine involution and calving interval in primiparous Nellore cows under grazing conditions, as well as would improve the pregnancy rate and calf performance at weaning, in the Brazilian Cerrado biome.

2. Methodology

The experiment was developed as a quantitative field research (Pereira et al. 2018). All management practices involving the cows were approved by the Animal Experimentation Ethics Committee, Universidade Federal de Goiás (process # 041-18).

2.1 Local, animals and treatments

The study was performed in a commercial Nellore herd in the Middlewest region of Brazil (Goiás State), Brazilian tropical savannah, Cerrado biome, characterized by the tropical climate Aw (Köppen-Geiger), 17º 47'45" S and 51º 02'07" W, 787 a.s.l. and annual rainfall of 1,587 mm, with well-defined rainy and dry seasons and seasonal forage offer. Eighty straight bred and pregnant Nellore heifers with 35 months of age, 369.2 ± 4.3 kg of body weight (BW) and parturition expected within a 45-day period during the dry season were randomly divided into four treatments (n=20) according to the nutritional supplementation as follows: CONTROL, receiving 134 g $head^{-1}$ d^{-1} of mineral salt enriched with 20% of urea during the pre and postpartum period; PRE, 300 g $head^{-1}$ d^{-1} of a protein-energy mixture (PBM) from the 210th gestational day until parturition; POST, 300 g $head^{-1}$ d^{-1} of PBM from calving until 90 days postpartum; PREPOST, 300 g $head^{-1}$ d^{-1} of PBM from the 210th gestational day until the 90th day postpartum. The levels per kg of the products used were: 1) Urea-enriched mineral supplement (150 g of Ca, 80 g P, 234 g Na, 10 g Mg, 40 g S, 6 g Zn, 2 g Cu, 80 mg I, 170 mg Co, 45 mg Se, 1.7 g Mn, 1.8 g Fe, 135 g N, 36 g flavoring agents and 80 g vehicle); 2) protein-energy supplement (70.4 g Ca, 57.6 g of P, 156 g of Na, 5.5 g of Mg, 12.74 g of S, 7.9 g of Zn, 500 mg of Cu, 84 mg of I, 80 mg Co, 18 mg Se, 1.6 Mn, 1.4 g Fe, 45 g N, 38% crude protein (CP), 28% non-proteic nitrogen (NPN) and 7524 kJ ME. Cows grazed on pastures paddocks of *Brachiaria brizantha* (Hochst ex. A. Rich Stapf) in a rotation system with high stocking rate (2.2 AU/Ha), and free access to water. The supplement was distributed in the feeders daily in the morning.

2.2 Reproductive evaluations

Cows were weighted on the 210th gestational day (initial weight, IW), on the calving (CW), when the complete uterine involution were diagnosed (WUI) and on the artificial insemination day (AIW). Beginning on the 7th day after calving, the cows were weekly submitted to the gynecological evaluation by rectal palpation and ultrasound to verify uterine involution and resumption of ovarian activity. The evaluations were repeated twice a week until the uterine horns were found to be small and symmetrical, which would characterize complete uterine involution. The cows were submitted to artificial insemination (AI) in a 90 d breeding season, beginning 90 days after the first week of calving season. Pregnancy diagnosis were performed 30 days

after AI through ultrasound examination and confirmed 60 days later. Calves were weighted at birth (WB) and weaning day (WW), with eight months of age.

2.3 Statistical analysis

All the data were analyzed by SAS v. 8.0 (SAS, 2000) software. Firstly, critical and consistency analyses were performed (frequency, frequency distribution and homogeneity of variance) using Univariate procedures. The experimental errors of the characteristics were normally and homogeneously distributed. Data were subjected to ANOVA using the GLM procedure (SAS, 2000). The mathematical model contained the fixed effect of treatments (CONTROL, PRE, POST, PREPOST). Cows included variables were initial body weight, weight at calving, at the day of complete uterine involution and at artificial insemination, whereas variables related to the calf were weight at birth and at weaning. Pregnancy rates were subjected to the frequency dispersion study using the chi-square test, by means of the FREQ procedure (SAS, 2000).

3. Results and Discussion

The composition of the pasture during the supplementation period was 961 g/kg of dry matter (DM); ash, 75.9 g/Kg/DM; crude protein (CP) 45.6 g/Kg/DM; acid detergent fiber (ADF) 535g/kg/DM and neutral detergent fiber (NDF) 755.1g/kg/DM, showing high fiber concentration and low CP, which are typical results for pastures in the end of the dry season (Detmann et al., 2014). The effect of energy-protein supplementation on weight changes of the cows is in Table 1. During the period between calving and complete uterine involution the cows gained on average 8.7 (CONTROL) to 20.2 kg (PRE) ($P<0.01$).

Table 1. Effect of energy-protein supplementation on weight changes of primiparous Nellore cows and their calves (kg± SEM).

	CONTROL	PRE	POST	PREPOST
Cow				
IW	401.2±3.0	393.9±2.7	401.5±2.4	395.9±2.6
CW	366.6±3.3[a]	351.0±2.9[b]	360.6±2.9[a]	346.2±2.7[c]
WUI	375.3±3.4[a]	371.2±3.1[a]	373.7±2.7[a]	356.5±2.9[b]
Weight Gain (calving-uterine involution)	8.7 (0.23)	20.2(0.65)	13.1 (0.39)	10.3 (0.41)
AIW	394.5±3.1[a]	402.0±2.7[b]	392.0±2.4[a]	386.7±2.9[c]
Weight Gain (Calving-AI)	27.9 (0.23)[a]	51.0 (0.43)[b]	31.4 (0.26)[a]	40.5(0.34)[c]
Calf				
WB	29.7±0.8[a]	29.4±0.7[a]	30.0±0.7[b]	29.6±0.7[a]
WW	185.1±2.2[a]	186.4±2.2[a]	195.4±2.1[b]	189.8±1.9[d]
Daily Weight Gain	0.66[a]	0.65[a]	0.68[b]	0.66[ac]

[a,b,c,d] Means with different letters in a row are different ($P<0.05$).

IW, initial weight; CW, weight on calving; WUI, weight on the complete uterine involution; AIW, weight on artificial insemination day. WB, weight on birth; WW, weaning weight
Source: Authors.

The results regarding days for complete uterine involution (DCUI) and pregnancy rates (PR) are exposed in Table 2.

Differences between treatments were found for DCUI (P<0.05). Uterine involution is a highly important physiological event in the reproductive life of a cow, because there is an uterine inflammation associated with bacterial contamination and endometrial remodeling.

The faster the uterine involution takes place, the more significant the reduction in the interval between parturitions, allowing the rate of one calf/cow/year. After calving, lactation causes an increase in the nutritional requirements and the cow is not able to meet those needs alone and experience a situation of negative energy balance (NEB) with the consequent suppression of reproductive activity. The metabolic effect of postpartum NEB affects negatively the inflammatory uterine response and delays uterine involution (Swangshan-Uthai et al., 2013).

Table 2. Effect of energy-protein supplementation on Days for Complete Uterine Involution (DCUI, Days ± SEM) and Pregnancy Rates (PR) of primiparous Nellore cows.

Variable	CONTROL	PRE	POST	PREPOST
DCUI	37.1±2.9[a]	31.3±2.7[b]	33.1±2.7[b]	25.4±2.1[c]
PR (%)	65	76	65	55

[a,b,c] Means with different letters in a row are statistically different p<0.05. Source: Authors.

Total digestible nutrients in the diet determine the return of ovarian activity during the postpartum and are associated to the body condition score (BCS) and uterine involution (Joner et al. 2018). In the present study all the cows had significantly loss of BCS from the first evaluation (210 days before calving) until artificial insemination, around 120 days after (6.25±0.10 vs 4.50±0.04, P<0.01), but no differences were verified between treatments after calving. Uterine involution happened more quickly in PREPOST cows (Table 1), but this event occurred within four to six weeks postpartum, as expected for suckled cows.

PRE cows gained weight more quickly than the others during the first five weeks postpartum. Initial body weight (IW) was similar at 210 pregnancy days (369.2 ± 4.3 Kg), but the body weight at calving (WC) was higher for CONTROL (p<0.01). Within the treatments, there were differences between IW and WC (P<0.001) and between treatments (P<0.05). All cows gained weight until the day of artificial insemination (AIW), but PRE cows, supplemented before calving gained more weight than the others (P<0.001). PRE cows gained 14.5% of body weight in this period, while CONTROL, POST and PREPOST gained 7.6, 8.7 and 10.5%, respectively. In the tropics, because breeding season is during the rainy period of the year, there is a concentration of parturitions late in the dry season, so during the last 50-60 days of pregnancy and early lactation period cows have lower food availability (quantitative and qualitative) and lose body reserves. This effect is most evident in primiparous because the cow is still growing and experiencing the first lactation (NRC, 2001). The nutritional quality of tropical grass decreases during the dry period, mainly by decreased crude protein content, which is recognized as the critical threshold for adequate microbial growth on the fibrous carbohydrates in basal forage, resulting in decreased intake and animal performance (Franco et al. 2017). The supplementation with nitrogenous compounds would improve the utilization of

low-quality forage by grazing cattle (Souza et al., 2010). Data associating the pre and postpartum nutrition and length of postpartum anestrous or physiological events related to reproductive efficiency of beef cows are inconsistent and may reflect interactions with many factors (Galindo et al. 2015). The accentuated body weight gain of PRE during postpartum period might be resulting of the higher dry matter intake and improved energy balance as a result of protein-energy supplementation before calving (McNamara et al., 2003). Lactation is one of the most important factors involved in postpartum anestrus in beef cows in a cow/calf system, but in this study all cows showed resumption of ovarian activity within 60 days after calving.

Body weight at DCUI was significantly lower for PREPOST cows in comparison with CONTROL and POST ($P<0.001$) and PRE ($P<0.01$). Milk yield of Nellore cows is lower than of *Bos taurus* cows, but it was showed that fat content was greater, as well as protein concentration (Calegare et al., 2009). Although milk quality was not evaluated in this study, the calf efficiency in weight gain during weaning period could be an indirect indicator of the dam's efficiency in providing the necessary nutritional support for the calf. Calf weight at weaning (WW) was higher than CONTROL for all treatments, with differences between CONTROL vs POST ($P<0.01$) and PRE vs POST ($P<0.05$), suggesting that the offer of an energy-protein supplement to the cow during the first 90 days postpartum, when the calf has an inactive rumen, leads to a quantitative and/or qualitative increase of milk yield. Interestingly, Calf WW of PREPOST, which dams were feed with the energy-protein supplement before and after calving were heavier than CONTROL and PRE, but the weight increment was not significant ($P<0.05$). Measurement of calf WW is a helpful tool to improve the selection of cows to be maintained in the herd for the next breeding season, because shows the maternal ability and the ability of calf to adapt to the nutritional environment.

The calving interval (overall mean= 362.8 ± 5.2 days) is smaller than those reported previously (Grossi et al. 2016). The calving interval around 12 months allows the cows to produce one calf/year (or about 5 calves during their entire productive life), the anticipation of the calving season and, as a consequence, increasing in the weaning calf weight. Providing the protein-energy supplementation during the pre and postpartum period produces interesting results, which lead to the reduction of the calving interval in up to 27 days. Similar result in a study evaluating the use of improved versus natural pastures was reported (Lobato et al., 2010). By providing better pre and postpartum nutritional level, PREPOST allowed to reach a calving interval shorter than those considered the ideal calving interval (365 days) to obtain one calf/cow/year. Feed supplementation can reduce the nutritional stress and enhance the onset of ovarian cyclicity after calving. *Bos indicus* cows have a greater ability to retain and deposit energy, and supplementation of grazing cows improves the nutrient utilization (Lopes et al. 2016). The combination of cow and calf performance in a Zebu herd in Africa management under similar conditions of the present study showed the best results when the dams were treated before and after calving with supplement content cottonseed cake and molasses (Sidibé-Anago et al., 2008). The main benefit of supplementing beef cattle with protein is the improvement of the nitrogen status in the animal´s metabolism (Detmann et al. 2014).

4. Final Considerations

In this experimental research we aimed to answer an important question about the reproduction and nutrition interface in Nellore cattle. It was possible to prove the initial hypothesis that a strategic protein-energy supplementation during pre and/or postpartum period would decrease days to complete uterine involution and calving interval in primiparous Nellore cows. Under the conditions of this study, for Nellore herds under extensive management regime in a tropical climate, the best nutritional supplementation strategy for primiparous cows involves the offer of supplement during the pre and postpartum periods. This treatment allows the cows to maintain their body condition, reduces the number of days needed for complete uterine involution, as well as for the first postpartum estrus, and allows the weaning of heavier calves. Future studies should be focused on monitoring the performance of calves born from these cows exposed to protein-energy supplementation in the pre and post calving period, i.e. birth weight and weight at 90 days.

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