DOI: 10.5433/1679-0359.2016v37n5p3277

# Supplementation of beef cattle grazing *Brachiariabrizantha* during the dry and rainy seasons: performance and carcass ultrasound prediction[1]

# Suplementação de novilhos de corte em pastagem de *Brachiariabrizantha* durante a estação seca e das águas: desempenho e predição ultrassonográfica de carcaça

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## Abstract

The aim of this study was to evaluate the influence of genetic group, sex and level of protein-energy supplementation on the performance and carcass traitsultrasound prediction of weaned calves Nellore and crossbred animals ½ Nellore x ½ Aberdeen Angus. A completely randomized design in a factorial 2x2x2, were used, with two levels of protein-energy supplementation, two sex and two genetic groups. Fifty-six animals were used (28 Nellore and 28 crossbred ½ Nellore x ½ Aberdeen Angus), equally divided between males and females, maintained on grazing *Brachiariabrizantha*cv. Marandu and evaluated in three experimental periods: period 1 = protein-energy supplementation in the dry season; period 2 = protein-energy supplementation during the rainy season; period 3 = only mineral supplementation. In the dry season, they were supplemented with levels of 0.5 and 1% of body weight (BW) and in the rainy season with 0 and 1% BW. Dry matter intake (kg day$^{-1}$, % BW, g kgBW$^{0.75-1}$) was estimated. In vivo ultrasound measurements of carcass were: loin eye area (LEA), fat thickness (FT) and rump fat thickness (RFT). There was influence of genetic group and protein-energy supplementation levels on average daily gain (ADG) of animals in period 1 and 2 ($P < 0.05$). Sex affected the ADG only in period 2, and the males had 754 gday$^{-1}$ and females, 582 g day$^{-1}$. There was no interaction of genetic group x sex x supplementation level. At the end of the experimental period (end of period 3), it was found that male animals and crossbred animals ½ Nellore x ½ Aberdeen Angus had higher ADG (716 and 748 g day$^{-1}$, respectively). The values of dry matter intake (DMI) were influenced by genetic group and sex, in all periods, verifying highest intake in crossbred animals ½ Nellore x ½ Aberdeen Angus, with better feed conversion for crossbred animals. Regarding ultrasound measurements taken on the carcass, the influence of sex on FT and RFT, it was observed, and the males showed higher values, 3.24

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Received: Sept. 29, 2015 - Approved: June 13, 2016

and 4.62 mm, respectively. LEA was influenced by protein-energy supplementation levels in the second period, herein animals receiving 1% of BW, showed higher values (56.04 $cm^2$) than those receiving 0.5% of BW supplement (48.38 $cm^2$). The use of protein-energy supplementation with 0.5% of BW in the dry season and 1% of BW in the rainy season, the best results of performance and contributes to larger loin eye area.
**Key words:** Dry matter intake. Genotype. Rib eye area. Sex. Yield performance.

## Resumo

Objetivou-se neste estudo avaliar a influência do grupo genético, sexo e níveis de suplementação proteico-energética sobre o desempenho e características de predição de carcaça de bezerros desmamados da raça Nelore e ½ Nelore x ½ Aberdeen Angus. Utilizou-se o delineamento inteiramente casualizado, em esquema fatorial 2x2x2, sendo dois níveis de suplementação, dois sexos e dois grupos genéticos. Foram utilizados 56 animais (28 Nelore e 28 ½ Nelore x ½ Aberdeen Angus), divididos igualmente entre machos e fêmeas, mantidos em pastagem de *Brachiariabrizantha* cv. Marandu e avaliados em três períodos experimentais: período 1= suplementação proteico-energética na estação seca; período 2= suplementação proteico-energética na estação chuvosa; período 3= apenas suplementação mineral. Na estação seca, suplementou-se com níveis de 0,5 e 1% do peso corporal (PC) e na estação chuvosa 0 e 1% do peso corporal. Foram estimados o consumo de matéria seca (kg $dia^{-1}$, % PC, g $kgPC^{0,75-1}$). As mensurações ultrassonográficas de carcaça *in vivo* foram: área de olho de lombo (AOL), espessura de gordura subcutânea (EGS) e espessura de gordura na garupa (EGG). Houve influência ($P < 0,05$) do grupo genético e do nível de suplementação no ganho médio diário (GMD) dos animais no período 1 e 2. O sexo influenciou o GMD apenas no período 2, sendo que os machos apresentaram 754g $dia^{-1}$ e as fêmeas, 582 g $dia^{-1}$. Não houve interação de grupo genético x sexo x nível de suplementação. Ao final do período experimental (final do período 3), verificou-se que os animais machos eanimais cruzados ½ Nelore x ½ Aberdeen Angus apresentaram maior GMD (748 e 716 g $dia^{-1}$, respectivamente). Os valores de consumo de matéria seca (MS) foram influenciados pelo grupo genético e pelo sexo, em todos os períodos avaliados, verificando-se maiores consumos em animais cruzados ½ Nelore x ½ Aberdeen Angus e em animais machos, sendo a conversão alimentar melhor em animais cruzados. Quanto às mensurações ultrassonográficas realizadas na carcaça, observou-se influência de sexo sobre EGS e EGG, sendo que os animais machos apresentaram valores maiores, de 3,24 e 4,62 mm, respectivamente. AOL foi influenciada pelo nível de suplementação proteico-energética, no período 2, sendo que animais recebendo 1% do PC em ambos os períodos apresentaram maiores valores (56,04 $cm^2$) do que aqueles recebendo 0,5% do PC em suplemento (48,38 $cm^2$). A utilização da suplementação proteico-energética com 0,5% do PC na estação seca e 1% do PCna estação chuvosa, apresenta melhores resultados de desempenho e contribui para maior área de olho de lombo.
**Palavras-chave:** Área de olho de lombo. Consumo de matéria seca. Desempenho produtivo. Genótipo. Sexo.

## Introduction

In order for production systems to ensure the profitability and acceptable degree of availability of animals throughout the year, it is indispensable to employ technologies and strategies such as dietary programs that include supplementation in the different periods of the year for animals reared on pasture, in addition to exploiting their genetic potential through crossbreeding and through the use of males and females for meat production (GOES et al., 2008).

Factors like weight, nutrition, age, sex, and genetics can influence the growth efficiency of cattle (BIANCHINI et al., 2008). As the genetic breeding or the genetic potential of an animal are improved, its nutritional requirements accompany this evolution, which means a higher need for dietary nutrients (PORTO et al., 2011).

Because pastures are subject to climatic variations over the year, it is important to adopt supplementation strategies so that the diet can meet the requirements of animals, allowing them to fully express their production potential and hence provide the desired return. This seasonality compromises mostly the balance between nitrogen compounds and carbohydrates. Nitrogen restriction generates a limitation in the growth of rumen microorganisms and reduces the cell wall digestibility, which in turn contributes to reducing the dry matter intake and consequently the performance of an animal (VILLELA et al., 2010).

In the dry season, supplementation with nitrogen compounds improves the cell wall degradation in forage plants and accelerates the feed passage rate. This strategy can boost feed intake, since there is a considerable reduction in the quality and quantity of available herbage during this season (PORTO et al., 2011). Thus, when animals receive protein supplementation and it provides an increase in animal performance, this result may be not only due to the increased herbage intake, but also the optimized use efficiency and digestibility of nutrients (SAMPAIO et al., 2009).

In the rainy season, when the pasture has better nutritional conditions and greater availability, supplementation may still be favorable as it may allow an increase in animal performance, promoting early slaughter or an earlier entry of these animals into reproductive stage (REIS et al., 2009).

The ultrasound technique allows producers to control the fattening degree and define the exact moment for slaughter, which contributes to reducing production costs. When in unsatisfactory amounts, the backfat thickness and marbling can influence the color, tenderness, and palatability of the end product (YOKOO et al., 2011). Females usually reach the recommended fat thickness for slaughter (3 mm) earlier than males, which suggests that they should be finished earlier (MARCONDES et al., 2008). The ultrasound technique also aids in genetic selection (YOKOO et al., 2011), since heritability for these traits is moderate to high (PINHEIRO et al., 2011).

The aim of this study was to evaluate the use of protein-energy supplementation on the performance of Nellore and 1/2 Nellore × 1/2 Aberdeen Angus weaned calves (male and female) in the dry and rainy seasons, as well as to obtain *in vivo* measurements of carcass characteristics by ultrasound.

## Material and Methods

The present study was conducted on Santo Antonio farm, located in the municipality of Cruzmaltina - PR, Brazil (24°3'55.54" S latitude, 51°34'26.04" W longitude, 416 m asl). Twenty-weight Nellore and 28 crossbred (½ Nellore × ½ Aberdeen Angus) cattle, equally divided into intact males and females, were used in the experiment, totaling 56 animals. The cattle were at approximately seven months of age, with average body weights of 246.89 ± 5.06 (males) and 226.89 ± 5.06 kg (females). Animals were vaccinated (foot and mouth disease and clostridiosis) and dewormed, and this procedure was adopted whenever necessary. The experiment was run as a completely randomized design with a 2 × 2 × 2 factorial arrangement that consisted of two sexes, two breed groups, and two supplementation levels.

The animals received protein-energy supplementation over the course of 196 days and mineral supplementation for 66 days. They were distributed into four lots and kept on *Brachiariabrizantha* cv. Marandu pastures in a total area of 18.93 ha. The paddocks were divided, and their new areas were 5.53, 4.74, 3.88, and 4.77 ha. Supplementation was provided daily and according to each treatment. The supplement contained soybean, corn, and urea (Table 1). Mineral salt was available *ad libitum*, in separate troughs.

The animals were driven to the subsequent paddock every seven days (the supplement followed the corresponding lots), such that all would undergo the same grazing conditions. The cattle were weighed on the first day and subsequently every 28 days. After the second weighing, feces were collected directly from the rectum while the animals were kept in a restraining chute for subsequent evaluation of voluntary intake, by using the indigestible neutral detergent fiber (iNDF) internal marker. Weighing was performed always in the early morning, and animals were not fasted before. Mineral supplementation was available *ad libitum*.

There were three experimental periods. In the dry season, the animals received concentrate (protein-energy supplementation) in the amount of 0.5 to 1.0% of their body weight, according to the proposed treatments. The cattle were separated, according to weight, into the following treatments (T): T1 = male Nellore, receiving 0.5% supplement; T2 = male Nellore, receiving 1.0% supplement; T3 = female Nellore, receiving 0.5% supplement; T4 = female Nellore, receiving 1.0% supplement; T5 = male ½ Nellore × ½ Aberdeen Angus, receiving 0.5% supplement; T6 = male ½ Nellore × ½ Aberdeen Angus, receiving 1.0% supplement; T7 = female ½ Nellore × ½ Aberdeen Angus, receiving 0.5% supplement; and T8 = female ½ Nellore × ½ Aberdeen Angus, receiving 1.0% supplement.

**Table 1.** Percentage composition of protein-energy supplement expressed in natural matter and levels of assurance of mineral salt.

| Ingredient | % |
|---|---|
| Groundcorn | 78 |
| Soybeanmeal | 20 |
| Urea | 1 |
| Calcareous | 1 |
| Guarantee levels of mineral salt (per kg of product): | |
| Calcium (min), g | 55.00 |
| Calcium (max), g | 68.00 |
| Phosphorus (min), g | 45.00 |
| Sulfur (min), mg | 4120.00 |
| Sodium (min), g | 152.00 |
| Cobalt (min), mg | 38.90 |
| Copper (min), mg | 1050.00 |
| Iron (min), mg | 1300.00 |
| Iodine (min), mg | 50.25 |
| Manganese (min), mg | 1000.00 |
| Selenium (min), mg | 9.00 |
| Zinc (min), mg | 2520.00 |
| Fluorine (max), mg | 450.00 |

After the dry season, the animals were reallocated to four new lots, with each treatment including animals from the same genetic group and sex, but which had been subjected to different supplementation levels in the previous period. In this second period, the animals were supplemented with concentrate in the amount of 0 and 1% of their body weight (protein-energy supplementation), which was important for determining the existence or absence of compensatory gain. The new treatments were thus as follows: T1 = male Nellore, receiving 0% supplement; T2 = male Nellore, receiving 1.0% supplement; T3 = female Nellore, receiving 0% supplement; T4 = female Nellore, receiving 1.0% supplement; T5 = male ½ Nellore × ½ Aberdeen Angus, receiving 0% supplement; T6 = male ½ Nellore × ½ Aberdeen Angus, receiving 1.0% supplement; T7 = female ½ Nellore × ½ Aberdeen Angus, receiving 0% supplement; and T8 = female ½ Nellore × ½ Aberdeen Angus, receiving 1.0% supplement.

In the third experimental period, the animals were kept under the same grazing regime on a *Brachiariabrizantha* cv. Marandu pasture and only mineral supplementation was provided. They were weighed at the beginning and end of this period. Over its course, the animals were grouped to form two new lots according to sex to prevent interaction between males and females.

The average weight gain was determined as the difference between the initial and final weights of each period separately, and the daily weight gain was calculated by dividing it by the number of days in each period. Subsequently, the total weight gain in the first two experimental periods was calculated.

Pasture samples were collected from the four paddocks individually, according to the frame-throwing technique, in which 0.25 $m^2$ samples of whole plant were collected at a height of approximately 5 cm from the soil at five points in each paddock, as recommended by Holderbaum and Sollenberg (1992). This collection was performed on day 0 and every 28 days, in periods 1 and 2. Samples were separated into two portions, one remaining as whole plant and the other divided into leaf, stem, and dead material. These were then packed in plastic bags, identified, and stored in a freezer until analyses. The fractions separated into leaf, stem, dead material, and whole plant, as well as feces samples, were dried in an oven at 55 ºC for 72 hand ground through a mill with 1 mm sieve for analyses of the dry matter (DM), mineral matter (MM), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) contents, as described by Mizubuti et al. (2009) (Table 2).

**Table 2.** Chemical composition of the supplement and *Brachiariabrizantha* pasture used in the feed to weaned and supplemented calves in the dry season (Period 1) and rainy (Period 2), besides the *in vitro* dry matter digestibility (IVDMD) and total digestible nutrients (TDN).

| Items (% DM) | Food | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Concentrated feed | *Brachiariabrizantha*pasture | | | | | | | |
| | | Period 1 | | | | Period 2 | | | |
| | | Wholeplant | Dead material | Stem | Leaf | Wholeplant | Dead Material | Stem | Leaf |
| DM (%) | 88.48 | 45.04 | 78.62 | 44.85 | 39.66 | 30.94 | 63.84 | 32.2 | 30.07 |
| MM (%) | 3.25 | 12.31 | 12.39 | 10.4 | 12.26 | 11.92 | 13.86 | 10.54 | 11.42 |
| CP (%) | 20.38 | 7.93 | 4.95 | 4.38 | 11.34 | 7.72 | 4.57 | 5.87 | 9.73 |
| EE (%) | 2.43 | 0.88 | 0.86 | 1.15 | 1.92 | 1.24 | 1.31 | 0.96 | 2.20 |
| NDF (%) | 33.94 | 78.96 | 77.47 | 75.12 | 66.41 | 70.48 | 78.20 | 79.23 | 74.66 |
| ADF (%) | 5.80 | 50.76 | 52.51 | 47.26 | 41.68 | 40.09 | 49.99 | 41.63 | 38.37 |
| IVDMD (%) | 97.81 | 65.72 | 53.18 | 61.16 | 77.95 | 74.46 | 53.69 | 72.90 | 81.45 |
| TDN (%) | 84.38 | 49.36 | 46.16 | 49.98 | 56.43 | 55.28 | 45.21 | 56.47 | 56.88 |

DM= dry matter; MM= mineral matter; CP= crude protein; EE= ethereal extract; NDF= neutral detergent fiber; ADF= acid detergent fiber; IVDMD= *in vitro* dry matter digestibility; TDN= total digestible nutrients. Period 1 (10/08/13 - 01/11/13): supplementation in dry season, receiving levels of 0.5 and 1% of body weight (BW). Period 2 (02/11/13 - 21/02/14): supplementation in rainy season, receiving levels of 0 and 1% BW.

The *in vitro* DM digestibility (IVDMD) of the samples of pasture and concentrate supplement was determined following the methodology of Tilley and Terry (1963).

Total digestible nutrients (TDN) were calculated based on the formula proposed by Patterson et al. (2000), as follows: TDN = [88.9 – (0.779 × ADF%)] (Table 2).

To determine the indigestible neutral detergent fiber (iNDF), the samples were incubated in the rumen of a fistulated cattle for 144 h, according to the methodology described by Detmann et al. (2012).

To estimate the dry matter intake, the animal's ingestion ability was assumed to be physically limited by the consumption of NDF from the diet when intake exceeded 1.2% of the body weight as NDF, according to the literature (MERTENS, 1994; SOUSA et al., 2008).

Intake was then estimated, first based on the NDF of pasture and supplement, which allowed the subsequent calculation of the amount of marker ingested. The indigestible neutral detergent fiber (iNDF) presented in the ingested feed was considered the internal marker. Next, iNDF analyses were performed to determine the concentration of this marker in the feces and in the diet. Having these results, we calculated the dry matter consumed (DMC), using the following formulae (SILVA; LEÃO, 1979): Excreted fecal DM = (100 × amount of marker supplied)/% of marker in fecal DM; DMC = (100 × total amount of internal marker excreted in feces)/% of internal marker in herbage, where DMC = kilograms of dry matter consumed.

Intake was estimated in kilograms of dry matter consumed (kg day$^{-1}$), as a function of body weight (%BW), and as a function of the metabolic weight (g kgBW$^{0.75-1}$). Analyses were performed at the Animal Nutrition Laboratory of the State University of Londrina.

At the end of the third experimental period, the animals were weighed for the last time and evaluated by ultrasound to determine carcass characteristics such as loin eye area (LEA), backfat thickness (BFT), and rump fat thickness (RFT). The LEA and BFT measurements were taken on the *longissimus* muscle, between the 12th and 13th ribs, and RFT was taken in the region where the *gluteus medium* and *biceps femoris* muscles connected.

An Aloka SSD500 ultrasound machine equipped with a 17 cm, 3.5 Mz linear probe with standoff pad to make contact with the animal was used. The images obtained with the device were analyzed using the Lince® software (M&S Consultoria Ltda., Pirassununga, SP, Brazil) by a technician with experience determining *in vivo* measurements in cattle.

Results were analyzed statistically using SAS statistical software (version 9.0). The adopted significance level was 0.05%.

## Results and Discussion

Because there was no interaction among genetic group × sex × supplementation levels, results were evaluated and discussed separately.

### *Animal performance*

The genetic group, sex, and supplementation level factors affected (P<0.05) the animal performance in all studied periods (Table 3).

The genetic group influenced (P<0.05) the final weight and the average daily gain (ADG) of the animals in all studied experimental periods; the ½ Nellore × Aberdeen Angus showed the best performance (Table 3). This finding can be explained by the effect of heterosis on crossbreeding and also because the Aberdeen Angus breed has greater aptitude for weight gain and is more precocious. In this experiment, we observed that in the first experimental period (dry season), there was a heavy frost that contributed to reducing the herbage quality, which can explain the average performance of 360 g day$^{-1}$ of animals supplemented during the dry season. In the second (rainy season) and third periods, the animals displayed more satisfactory gains: 668 and 639 g day$^{-1}$, respectively, probably due to the better herbage conditions in that season (Table 2), in addition to the protein-energy supplementation given in period 2.

**Table 3.** Animal performance of different genetic groups, sex and levels of supplementation kept in Brachiariabrizantha cv. Marandu pasture throughout the experimental period.

| Sourcesofvariationt | | Performance characteristics (kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Period 1 | | | Period 2 | | | Period 1 and 2 | Period 3 | | |
| | | Initial weight | Final weight | ADG | Initial weight | Final weight | ADG | ADG | Initial weight | Final weight | ADG |
| Geneticgroup | | | | | | | | | | | |
| 1/2 Nellore x 1/2 Aberdeen Angus | | 243.18 | 282.89 a | 0.473 a | 282.95 a | 364.72 a | 0.730 a | 0.619 a | 364.72 a | 411.27 a | 0.716 a |
| Nellore | | 230.61 | 251.29 b | 0.246 b | 251.23 b | 319.03 b | 0.605 b | 0.452 b | 319.03 b | 355.52 b | 0.561 b |
| Sex | | | | | | | | | | | |
| Female | | 226.89 b | 256.57 b | 0.353 | 256.57 b | 321.71 b | 0.582 b | 0.484 b | 321.71 b | 356.11 b | 0.529 b |
| Male | | 246.89 a | 277.61 a | 0.365 | 277.61 a | 362.04 a | 0.754 a | 0.587 a | 362.04 a | 410.68 a | 0.748 a |
| Levels of supplementation (% BW) | | | | | | | | | | | |
| Period 1 | Period 2 | | | | | | | | | | |
| 0.5 | 0 | 235. 14 | 260.93 | 0.307 b | 262.19 | 326.69 b | 0.576 c | 0.466 c | 326.69 b | 373.77 | 0.724 a |
| 0.5 | 1.0 | - | - | - | 259.66 | 353.16 a | 0.835 a | 0.603 a | 353.16 a | 392.59 | 0.607 bc |
| 1.0 | 0 | 238.64 | 273.25 | 0.412 a | 273.73 | 334.45 ab | 0.542 c | 0.504 bc | 334.45 ab | 378.45 | 0.677 ab |
| 1.0 | 1.0 | - | - | - | 272.76 | 353.19 a | 0.718 b | 0.569 ab | 353.19 a | 388.77 | 0.547 c |
| Average | | 236.89 | 267.09 | 0.36 | 267.09 | 341.88 | 0.668 | 0.536 | 341.88 | 341.88 | 0.639 |
| CV (%) | | 11.29 | 9.72 | 45.30 | 9.76 | 8.30 | 14.69 | 17.34 | 8.30 | 8.30 | 19.1 |

Period 1 (P1: 10/08/13 - 01/11/13): supplementation in dry season, receiving levels of 0.5 and 1% of body weight (BW). Period 2 (02/11/13 - 21/02/14): supplementation in rainy season, receiving levels of 0 and 1% BW. Period 3 (P3: 22/02/14 - 29/04/14): only mineral supplementation. ADG= average daily gain. CV= coefficient of variation. Means followed by different letters in the same column, the same source of variation differ P (<0.05).

**Table 4.** Estimated values of dry matter intake (kg/day, % BW and g/kg BW 0.75) in weaned calves kept under grazing *Brachiariabrizantha* cv. Marandu and supplemented with protein-energy concentrate in period 1 (the dry season) and period 2 (the rainy season) and supplemented only with mineral supplementation in period 3.

| Sourcesofvariation | | Dry matter intake | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Period 1 | | | Period 2 | | | Period 1 and 2 | | | Period 3 | | |
| | | kg $day^{-1}$ | % BW | g $kgBW^{0.75-1}$ | kg $day^{-1}$ | % BW | g $kgBW^{0.75-1}$ | kg $day^{-1}$ | % BW | g $kgBW^{0.75-1}$ | kg $day^{-1}$ | % BW | g $kgBW^{0.75-1}$ |
| GeneticGroup | | | | | | | | | | | | | |
| 1/2 Nellore x 1/2 Aberdeen Angus | | 5.65 a | 2.13 | 85.93 a | 6.75 a | 2.07 | 87.87 a | 6.33 a | 2.1 | 87.23 a | 6.50 a | 1.86 | 80.35 a |
| Nellore | | 5.09 b | 2.13 | 83.71 b | 6.06 b | 2.07 | 85.49 b | 5.66 b | 2.1 | 84.81 b | 5.76 b | 1.86 | 77.92 b |
| Sex | | | | | | | | | | | | | |
| Female | | 5.18 | 2.13 | 84.07 | 6.11 b | 2.07 | 85.70 b | 5.78 | 2.1 | 85.27 | 5.82 b | 1.86 | 78.16 b |
| Male | | 5.56 | 2.13 | 85.57 | 6.70 a | 2.07 | 87.65 a | 6.21 | 2.1 | 86.76 | 6.44 a | 1.86 | 80.10 a |
| Levels of supplementation (% BW) | | | | | | | | | | | | | |
| Period 1 | Period 2 | | | | | | | | | | | | |
| 0.5 | 0 | 4.94 b | 2.02 | 79.88 b | 5.41 b | 1.86 | 76.73 b | 5.22 b | 1.93 | 78.13 d | 5.86 | 1.86 | 78.25 |
| 0.5 | 1.0 | 5.20 ab | 2.02 | 80.93 b | 7.24 a | 2.28 | 96.14 a | 6.51 a | 2.17 | 90.16 b | 6.29 | 1.86 | 79.67 |
| 1.0 | 0 | 5.55 a | 2.24 | 88.77 a | 5.75 b | 1.86 | 77.85 b | 5.60 b | 2.02 | 82.32 c | 6.16 | 1.86 | 79.22 |
| 1.0 | 1.0 | 5.79 a | 2.24 | 89.69 a | 7.21 a | 2.28 | 95.98 a | 6.65 a | 2.26 | 93.46 a | 6.21 | 1.86 | 79.39 |
| Average | | 3.36 | 2.13 | 84.76 | 6.41 | 2.07 | 86.72 | 5.86 | 2.08 | 84.92 | 6.14 | 1.86 | 79.17 |
| CV[1] (%) | | 10.53 | 0.00 | 2.64 | 8.52 | 0.00 | 2.18 | 9.41 | 0 | 2.39 | 8.35 | 0.00 | 2.13 |

Period 1 (P1: 10/08/13 - 01/11/13): supplementation in dry season, receiving levels of 0.5 and 1% of body weight (BW). Period 2 (02/11/13 - 21/02/14): supplementation in rainy season, receiving levels of 0 and 1% BW. Period 3 (P3: 22/02/14 - 29/04/14): only mineral supplementation. DMI= dry matter intake; CV= coefficient of variation. Averages with different letters in the same column and the same source of variation differ P (<0.05). [1]Value equals zero, due to the large similarity of results.

There was an influence ($P<0.05$) of sex on the ADG values in periods 2 and 3, but not in period 1 (Table 3). In period 1, this probably occurred because the animals had not yet reached puberty and thus were not affected by the sex hormones.

The effect observed in periods 2 and 3, with higher values in males, can be explained by the presence of androgynous hormones, which are responsible for the spread of satellite cells. According to Dayton and White (2007), these satellite cells increase the protein-synthesis ability, thereby promoting muscle hypertrophy. Therefore, there is a possibility that males have a larger amount of muscle fibers from birth, which leads to higher body weight values in different stages of life. Moreover, males show a natural capacity to gain more weight than females (MARTINS et al., 2000).

Patterson and Salter (1985) reported that the testosterone produced in the testicles of males and the estradiol-17β produced in the ovary of females are anabolic agents that provide muscle growth. However, few studies have been carried out to evaluate the importance of ovarian hormones in muscle growth (SITNICK et al., 2006).

Ítavo et al. (2007) used 36 animals (18 males and 18 females), distributed into two treatments: on pasture (creep-feeding and weaning at 210 days) and in the feedlot (early weaning, at 90 days) and did not find differences in average daily gain between the sexes, in the same system. Marcondes et al. (2008), on the other hand, used two levels of concentrate in 45 feedlot-finished Nellore cattle and found differences ($P<0.05$) among different sex categories, including intact and castrated males and females, and higher weight gain in uncastrated males and lower weight gain in females. These differences were attributed to the fact that intact males grow 10 to 20% more than castrated animals.

The supplementation level influenced ($P<0.05$) the ADG of the animals in all periods (Table 3). In the first period, the animals that received protein-energy supplementation at the highest level (1% BW) obtained gained more weight, while in the second period the highest weight gain was found in cattle receiving 0.5% supplementation in period 1 and 1% in period 2, followed by those that received 1% BW in both periods. This indicates that supplementation provided higher weight gains, and thus there was an improvement in ruminal efficiency. Supplementation in period 1 considerably influenced the performance in period 2, and the animals that received the lowest level of supplementation (0.5% BW) in period 1 had the highest gains in period 2 (576 and 835 g day$^{-1}$), indicating that there was compensatory gain (Table 3).

Supplementation in period 2 influenced ($P<0.05$) the average daily gain in period 3. Animals not supplemented during period 2 showed higher ADG (0.724 and 0.677 g day$^{-1}$). These animals entered period 2 with a lower weight than those supplemented with 1% of their BW, which reinforces the occurrence of compensatory gain, as occurred in period 2, under the influence of supplementation in period 1 (Table 3).

When the animals were given lower levels of protein-energy supplementation in period 1 (dry season) and zero protein supplementation in period 2, they had a higher ADG at the end of period 3, whose only supplementation provided was mineral. This finding is explained by the compensatory gain (Table 3).

*Dry matter availability*

The quantity and quality of available herbage are related to the dry matter intake and performance of animals (BARBOSA et al., 2007). The herbage availability found in period 1 was 4311.87 kg DM ha$^{-1}$, whereas in period 2 it was 3219.82 kg DM ha$^{-1}$. In the latter, despite representing the rainy season and lower amount of fresh matter, this value was lower due to the high dry matter content seen in period 1. According to NRC (1996), when the herbage allowance is lower than 2000 kg DM ha$^{-1}$, intake is limited and the grazing time is extended, contributing to performance losses. Intake is also limited when the herbage has CP values lower than 6 to 8% DM.

When animals have the opportunity to select the pasture, their performance may improve due to the increased intake (BARBOSA et al., 2007). In our study, the animals were likely able to select the pasture, due to the higher herbage availability values. Besides, supplementation stimulated dry matter intake.

*Dry matter intake*

There was an effect (P<0.05) of genetic group and supplementation level on dry matter intake (kg day$^{-1}$ and g kgBW$^{0.75-1}$) in period 1, in which the ½ Nellore × ½ Aberdeen Angus animals displayed greater intake, as well as those supplemented at 1% (Table 4). Additionally, the effect (P<0.05) of genetic group on dry matter intake (kg day$^{-1}$ and g kgBW$^{0.75-1}$) was observed in all studied periods, with crossbred animals showing higher values (Table 4).

The weight and size of the animal directly influence its feed intake; therefore, heavier and larger animals usually consume more in order to meet their maintenance requirements (VITTORI et al., 2007). This can explain the why the ½ Nellore × ½ Aberdeen Angus animals showed higher intake values, since they displayed greater performance during the experiment.

In periods 2 and 3, males consumed more DM (kg day$^{-1}$ and g kgBW$^{0.75-1}$) (Table 4). This difference (P<0.05) in DM intake between the sex categories, with higher values for males, can be explained by the physiological maturity, sex condition, and stage of development of the animals (SANTOS, 2014), because nutritional and dynamic requirements in body tissue deposition are different between males and females, directly affecting their feed intake (NRC, 1996). This difference was not found in the first period because of the lack of interference of factors such as physiological maturity and development stage of the animals (Table 4).

Feed intake is determined by the animal's ability to metabolize nutrients, and it is influenced by sex hormones (ORSKOV, 1990). These hormones also affect the development of the animal, e.g., the testosterone, produced by the testicles in intact males, which acts in the anabolism of endogenous nitrogen, providing them with greater weight gains and better feed efficiency (RESTLE et al., 2000), which explains the higher intake values shown by males.

Animals that received higher levels of protein-energy supplementation in periods 1 and 2 showed higher DM intakes (kg day$^{-1}$ and g kgBW$^{0.75-1}$). One of the objectives of supplementation clearly explains this finding, because it consists of providing an improvement in the digestibility of the available herbage and maximizing its consumption (BARBOSA et al., 2007). Sousa et al. (2008) worked with lactating crossbred dairy cows and observed an increase in voluntary total dry matter intake as the amount of concentrate supplied was elevated in a regime of animals grazing on *Brachiaria* grass pastures.

Cabral et al. (2008) worked with feedlot sheep and found a relationship between dry matter intake and body weight, reporting an increasing linear effect, explained by the fact that heavy animals have an elevated dry matter intake due to higher energy requirements for maintenance. High correlations were observed between the final weights and the respective intakes in each period (0.923, 0.844, and 0.981 for periods 1, 2, and 3, respectively) (Table 5).

**Table 5.** Pearson correlation coefficients between weight and dry matter intake during the experimental period.

| | Initial bodyweight P1 | Final bodyweight P1 | Final bodyweight P2 | DMI kg day$^{-1}$ P1 | DMI kg day$^{-1}$ P2 | DMI kg day$^{-1}$ P3 | DMI kgday$^{-1}$ P1P2 |
|---|---|---|---|---|---|---|---|
| Initial bodyweight P1 | 0.850* | 0.752* | 0.747* | 0.822* | 0.685* | 0.758* | 0.802* |
| Final bodyweight P1 | | 0.883* | 0.876* | 0.923* | 0.671* | 0.942* | 0.844* |
| Final bodyweight P2 | | | 0.973* | 0.801* | 0.844* | 0.971* | 0.890* |
| Bodyweight P3 | | | | 0.777* | 0.762* | 0.981* | 0.799* |
| DMI kg/day P1 | | | | | 0.665* | 0.806* | 0.829* |
| DMI kg/day P2 | | | | | | 0.753* | 0.969* |
| DMI kg/day P3 | | | | | | | 0.836* |

DMI: dry matter intake. Period 1 (P1: 10/08/13 - 01/11/13): supplementation in dry season, receiving levels of 0.5 and 1% of body weight (BW). Period 2 (02/11/13 - 21/02/14): supplementation in rainy season, receiving levels of 0 and 1% BW. Period 3 (P3: 22/02/14 - 29/04/14): only mineral supplementation. *0.01 probability.

In addition to the variation in dry matter intake due to body weight, the differences in the composition of gain, stemming from the effect of body weight changes, are important. The composition of gain varies according to the production stage in which the animal is concerning the deposition of muscle or adipose tissue, with the energy requirement for fat deposition being much higher (VALADARES FILHO et al., 2006).

With respect to feed conversion, differences were detected between the genetic groups in all experimental periods, with better results found for the crossbred animals (Table 6). This suggests that heterosis may provide better performance results.

The sex factor affected feed conversion (Table 6); males displayed better feed conversion in periods 2 and 3. The lack of significance (P>0.05) in period 1 is justified by the age and growth stage of the animals.

The results found for the sex categories are similar to those reported by Coutinho Filho et al. (2006), who evaluated 28 Santa Gertrudis cattle (14 intact males and 14 females) and found better performance in males and worse feed conversion in females. Likewise, Marcondes et al. (2008) evaluated the production parameters of 45 Nellore cattle (14 intact males, 15 castrated males, and 15 females) and found lower feed conversion values in females.

As regards the protein-energy supplementation level, the animals that received the lowest levels (0.5% BW) in period 1 and those which did not receive this supplementation in period 2 showed the best feed conversion values at the end of period 3 (Table 6). This fact can be explained by the compensatory-gain effect at the end of the periods of protein-energy supplementation.

**Table 6.** Feed conversion in weaned calves kept under grazing *Brachiariabrizantha* cv. Marandu and supplemented with protein-energy concentrated in dry season (period 1) and the rainy season (period 2) and supplemented with minerals in the period 3.

| Sources of variation | | Feed conversion (kgDM kg$^{-1}$ gain weight) | | | |
|---|---|---|---|---|---|
| | | Period 1 | Period 2 | Period 1 and 2 | Period 3 |
| Genetic Group | | | | | |
| 1/2 Nellore x 1/2 Aberdeen Angus | | 12.96 b | 9.08 b | 9.57 b | 9.29 b |
| Nellore | | 28.78 a | 11.38 a | 14.40 a | 10.97 a |
| Sex | | | | | |
| Female | | 20.69 | 11.26 a | 13.14 | 10.96 a |
| Male | | 21.05 | 9.21 b | 10.82 | 9.31 b |
| Levels of supplementation (% BW) | | | | | |
| Period 1 | Period 2 | | | | |
| 0.5 | 0 | 20.62 | 10.30 | 12.11 | 8.09 a |
| 0.5 | 1.0 | 25.20 | 9.11 | 11.08 | 10.16 a |
| 1.0 | 0 | 22.94 | 10.85 | 12.51 | 9.40 a |
| 1.0 | 1.0 | 14.71 | 10.67 | 12.24 | 12.88 b |
| Average | | 20.98 | 10.2 | 12.17 | 10.09 |
| CV (%) | | 76.27 | 18.89 | 23.42 | 20.36 |

Period 1 (P1: 10/08/13 - 01/11/13): supplementation in dry season, receiving levels of 0.5 and 1% of body weight (BW). Period 2 (02/11/13 - 21/02/14): supplementation in rainy season, receiving levels of 0 and 1% BW. Period 3 (P3: 22/02/14 - 29/04/14): only mineral supplementation. Means with different letters in the same column, the same source of variation differ P (<0.05). CV= coefficiente of variation; DM= dry matter.

*Carcass characteristics determined by ultrasound*

The genetic group did not influence the following carcass characteristics: loin eye area (LEA), backfat thickness (BFT), and rump fat thickness (RFT) (Table 7).

There was an influence (P<0.05) of sex on BFT and RFT, with higher values found in the males, but no differences were detected for LEA (Table 7). Marcondes et al. (2008) worked with three sex categories (intact males, castrated males, and females) receiving supplementation at two levels, together or in groups, and found differences (P<0.05) for the carcass ultrasound measurements between males and females for LEA. For BFT and RFT, however, the sexes did not differ.

Fat deposition is usually in larger in females, both subcutaneously and intramuscularly (MARCONDES et al., 2008). Females mature earlier, reaching fat deposition in less time than males (SANTOS, 2014). In the current study, however, this variable was at higher values in males, because the females had not reached maturity, which is the period of greater deposition of adipose tissue (PAULINO et al., 2009).

The supplementation level in period 2 had a remarkable influence on LEA, with highest values observed in animals supplemented with 1% BW (P<0.05); this can be explained by the fact that these animals were heavier at the end of the experiment and because of the greater nutrient input from supplementation during periods 1 and 2. For BFT, the difference (P<0.05) occurred between the animals that received only 0.5% BW as protein-energy supplementation in period 1 in relation to those receiving 0.5% BW in period 1 and 1% BW supplementation in period 2. Supplementation levels did not influence (P>0.05) fat deposition on the rump (Table 7).

**Table 7.** Measurements of the ultrasound characteristics carcass weaned calves undergoing supplementation in the dry (period 1) and rainy (period 2) kept on pasture *Brachiariabrizantha*, evaluated at the end of period three.

| Sourcesofvariation | | Variables | | |
|---|---|---|---|---|
| | | LEA ($cm^2$) | BFT (mm) | RFT (mm) |
| Genetic Group | | | | |
| 1/2 Nellore x 1/2 Aberdeen Angus | | 54.06 | 3.01 | 4.41 |
| Nellore | | 50.26 | 3.13 | 4.38 |
| Sex | | | | |
| Female | | 50.56 | 2.90 b | 4.18 b |
| Male | | 53.76 | 3.24 a | 4.62 a |
| Levels of supplementation (% BW) | | | | |
| Period 1 | Period 2 | | | |
| 0.5 | 0 | 48.38 b | 2.92 b | 4.20 |
| 0.5 | 1.0 | 53.77 ab | 3.33 a | 4.66 |
| 1.0 | 0 | 50.44 ab | 3.03 ab | 4.32 |
| 1.0 | 1.0 | 56.04 a | 3.00 ab | 4.41 |
| Average | | 52.47 | 3.07 | 4.39 |
| CV(%) | | 15.31 | 17.04 | 15.43 |

LEA= loin eye area; BFT: backfat thickness; RFT: rump fat thickness. CV= coefficient of variation. Period 1 (P1: 10/08/13 - 01/11/13): supplementation in dry season, receiving levels of 0.5 and 1% of body weight (BW). Period 2 (02/11/13 - 21/02/14): supplementation in rainy season, receiving levels of 0 and 1% BW. Period 3 (P3: 22/02/14 - 29/04/14): only mineral supplementation. Means with different letters in the same column, the same source of variation differ P (<0.05).

Reaffirming the previous assertion, the highest LEA was found in the animals receiving the highest levels of protein-energy supplementation in periods 1 and 2. The difference ($P<0.05$) was observed between the treatments that had the highest and lowest supplementation levels (48.38 and 56.04 $cm^2$) (Table 7). The loin eye area is closely related to the weight of the animal (VAZ et al., 2002), and, thus, animals which received higher levels of supplementation showed better performance and consequently a larger loin eye area.

Backfat thickness, in turn, was at higher values in the animals receiving protein supplementation in the amounts of 0.5 and 1% BW in periods 1 and 2, respectively (Table 7). As stated by Restle et al. (2001), supplementation ensures a better fattening degree, providing higher gains and energy input and consequently contributing to higher fat deposition.

## Conclusions

For weaned calves (males and females), protein-energy supplementation is recommended at the proportion of 0.5% of their body weight during the dry season and at 1% of their body weight in the rainy season, because animals display greater performance efficiency, dry matter intake, and *in vivo* ultrasound carcass measurements.

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