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Intake, apparent digestibility, and nutrient requirements for growing Nellore heifers and steers fed two levels of calcium and phosphorus

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ABSTRACT

Nutrient apparent digestibility, intake, performance, microbial efficiency, and energy and protein requirements for growing Nellore heifers and steers were evaluated, fifty animals were used, 32 Nellore heifers and 18 Nellore steers. Four animals of each gender used as baseline reference animals were slaughtered at the beginning of the experiment. Four animals from each gender were fed at MAIN receiving 11 g/kg BW, whereas 10 steers and 24 heifers were assigned to the ADLIB group. The ADLIB heifers were divided further into 4 groups according to the dietary treatment: (1) Ca and P fed at their proposed requirements (CaPR) with a 50:50 roughage:concentrate (R:C) diet, (2) CaPR with a 70:30 R:C diet, (3) 43% of their proposed requirements for Ca and 80% of their requirements for P (CaPL) with a 50:50 R:C diet, and (4) CaPL with a 70:30 R:C diet. The ADLIB and MAIN steers were fed CaPR with a 50:50 R:C diet. Half of the ADLIB steers and heifers were slaughtered at day 50; the other ADLIB animals were slaughtered after 100 days of the feeding period, whereas all MAIN animals were slaughtered at day 100. Total feces and urine were collected from all animals for 72 h prior to slaughter. After slaughter, EBW was measured. The NEm and MEm requirements were estimated by exponentially relating heat production with metabolizable energy intake; NEg was estimated from EBW and EBG. The NPg was estimated from EBG and RE. Dry matter digestibility and the apparent absorption and retention of Ca and P were similar across Ca and P treatments. Final body weight, and consequently ADG, was greater ($P < 0.05$) for heifers receiving the high concentrate compared to the low concentrate diet, but dietary Ca and P concentration did not affect ($P > 0.05$) performance. The NEm and MEm requirements were 294 and 496 kJ/kg $EBW^{0.75}$, respectively. Net protein for maintenance was 1.28 g/kg $BW^{0.75}$ and NEg and NPg were estimated from the following equations: $NEg = 0.222 \times EBW^{0.75} \times EBG^{0.6263}$ and $NPg = 137.53 \times EBG - 0.038 \times RE$, respectively. Under the conditions of this experiment, reducing the dietary concentrations of Ca and P had no significant impact on intake, digestibility, or performance of growing Nellore heifers and steers.

1. Introduction

Beef production in Brazil is primarily a pasture-based system, with Nellore cattle reaching slaughter weight by 24 months of age. Although this system has a low cost for feed inputs, cattle slaughtered at 24 months of age typically have low carcass quality. Paulino et al. (2006) suggested that slaughtering Nellore beef cattle at 18 months of age is a viable method to increase carcass quality. However, in Brazil, weaning of calves coincides with the drought season. Therefore, for achieving the slaughter at 18 months, weaned calves must be fed in a feedlot system to provide sufficient energy to increase their growth rate.

The BR CORTE system (Valadares Filho et al., 2010) provides estimates of the nutrient requirements for Zebu cattle based on

Abbreviations: ADG, average daily gain; ADLIB, ad libitum; AS, ammonium sulfate; BW, body weight; CaPR, 100% of Ca and P requirements; CaPL, 43% of Ca requirement and 80% of P requirement; CP, crude protein; DE, digestible energy; DM, dry matter; EBG, empty body weight gain; EBW, empty body weight; EE, ether extract; HP, heat production; KPH, the amount of kidney, pelvic, and heart fat; MAIN, maintenance; MEI, metabolizable energy intake; MEm, metabolizable energy requirement for maintenance; MPm, metabolizable protein requirement for maintenance; N, nitrogen; NDF, neutral detergent fiber; NEm, net energy for maintenance; NEg, net energy for growth; NFC, non-fiber carbohydrates; NPg, net protein requirement for growth; NPm, net protein requirement for maintenance; R:C, roughage:concentrate ratio; RE, retained energy; TDN, total digestible nutrients; U, urea

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experiments conducted in Brazil over the last 2 decades. However, the majority of experiments have used finishing cattle including about 80% bulls (Chizzotti et al., 2007; Marcondes et al., 2009). Thus, there is a lack of information about nutritional requirements and performance of growing Zebu cattle differing in gender and physiological conditions. Furthermore, the number of experiments evaluating Ca and P requirements of Zebu cattle is limited (Prados et al., 2015). Factors including age, body weight, productivity level, pregnancy, and environment have been reported to influence the Ca and P requirements of cattle.

The aim of this study was to evaluate the intake and digestibility of DM and nutrients, performance, microbial efficiency, and energy and protein requirements of growing Nellore heifers and steers fed 2 levels of Ca and P.

2. Materials and methods

2.1. Animals, design, and treatments

This experiment was conducted at the Experimental Feedlot of the Animal Science Department, Viçosa, MG, Brazil. Animal care and handling of the animals followed guidelines set by the Universidade Federal de Viçosa. Fifty Nellore cattle were used, these included 32 heifers and 18 steers with an average initial body weight of 180 ± 25.0 kg and 150 ± 25.1 kg, respectively, and an average age of 8 ± 1.0 months. Heifers were divided into the following groups: 4 animals were randomly selected as the control group and were slaughtered at the beginning of the experiment to evaluate the initial body composition, 4 animals were fed at MAIN (11 g/kg BW), whereas 24 heifers were allowed free choice access to feed throughout the experiment. These 24 ADLIB animals were divided into 4 groups and fed with the following treatments relative to the Valadares Filho et al. (2010) recommendations for Ca and P: (1) Ca and P fed at their proposed requirements (CaPR) with a 50:50 roughage:concentrate (R:C) diet, (2) CaPR with a 70:30 R:C diet, (3) 43% of their proposed requirements for Ca and 80% of their requirements for P (CaPL) with a 50:50 R:C diet, and (4) CaPL with a 70:30 R:C diet. Steers were divided into 3 groups: 4 steers were used as the control group, 4 steers were fed at MAIN, and 10 steers received the ADLIB treatment. All steers were fed CaPR with a 50:50 R:C diet. Half of the ADLIB heifers and steers were slaughtered at day 50; others were slaughtered at day 100 of the feeding period. All MAIN animals were slaughtered at day 100. Total feces and urine were collected from all animals starting 72 h prior to slaughter.

This experiment had a completely randomized design with a $2 \times 2 + 1$ factorial arrangement of treatments. Diets were formulated according to BR CORTE system (Valadares Filho et al., 2010) to achieve an ADG of 0.3 kg. This diet consisted of fresh sugarcane and a concentrate supplement formulated of ground corn, soybean meal, limestone, common salt, and mineral mix (Table 1). The DM content of sugarcane was assessed 3 times each week to adjust DM of the amount of sugarcane and supplement provided to the animals which the amount of U and AS (9:1) supplied to the animals; the CP content of diets was adjusted to maintain at 124 g CP/kg DM (19.8 g of N/kg DM).

Fresh feed was provided twice a day for the animals and adjusted daily to maintain orts at approximately 5–10% of the total feed supplied to ADLIB cattle; drinking water was continuously available to all the animals. The amount of feed supplied was recorded daily; additionally, the ingredients in the concentrate were sampled each time concentrate was manufactured. Composite feed samples were obtained for each feeding period in proportion to the amount of each ingredient in the diet mixture. Feed samples (sugarcane and orts) were grouped proportionally for every 7-d period, composited, lyophilized, and ground through a 1-mm mesh sieve. At the end of each 7-d period, a composite sample of orts was performed each 50-d period in proportion to the weight of weekly DM. Sugarcane samples from each week were analyzed.

Table 1
Proportions of feed in each diet and its composition on DM basis.

Items	Diets[a]				
	70:30 CaPR	70:30 CaPL	50:50 CaPR	50:50 CaPL	Sugarcane
Proportion (g/kg DM)					
Fresh sugarcane	700	700	500	500	–
Ground corn	246	246	411	411	–
Soybean meal	45.1	45.1	75.2	75.2	–
Dicalcium phosphate	4.8	2.4	2.5	0.00	–
Salt	0.4	0.4	0.7	0.7	–
Limestone	3.1	0.00	5.3	2.2	–
Mineral mix[b]	0.24	0.24	0.35	0.35	–
Sand	0.00	5.5	5.3	10.8	–
Chemical composition (g/kg DM)					
DM	488	488	599	599	322
CP	162	162	163	162	34
NDF	397	397	326	326	503
Ca	5.7	3.9	5.2	3.4	4.3
P	2.8	2.3	2.7	2.2	1.2

[a] 70:30 and 50:50 = roughage:concentrate ratios, CaPR = 100% of Ca and P requirements, CaPL = 43% of Ca requirement and 80% of P requirements.

[b] Mineral mixed composition = 29.2 g/kg of calcium, 0.70 g/kg of phosphorus, 2.11 g/kg of magnesium, 0.89 g/kg of potassium, 0.31 g/kg of sodium, 63.5 g/kg of sulfur, 348 mg/kg of cobalt, 2.56 mg/kg of chromium, 3296 mg/kg of copper, 2088 mg/kg of iron, 4673 mg/kg of manganese, 7817 mg/kg of zinc, and 318 mg/kg of selenium.

2.2. Measurements and analyses

Total tract apparent digestibility was assessed during the 72-h immediately before each slaughter date; total excreted feces and urine were collected. Feces were sampled from dropping on concrete floor. At the end of 24-h of sampling, the buckets containing the samples were weighed and homogenized; a sub-sample per day was retained, weighed, dried in a forced-draft oven (55 °C), and ground through a knife mill with a 1-mm mesh sieve. Subsequently, one composite sample per animal was created based on the DM weight for every collection day.

Urine was collected with the aid of collecting funnels attached to the steers with hoses conducting urine to carboys containing 200 mL of 20% H_2SO_4. The carboys were kept in polyethylene boxes with ice to reduce N loss. For heifers, a 2-way Foley catheter (No. 22, Rush Amber, Kamuting, Malaysia) with a 30-mL balloon was utilized. A polyethylene tube was attached to the free end of the catheter, through which the urine would flow into a plastic container with a lid; each container held 200 mL of 20% H_2SO_4. After collection, the total excreted weight of the urine was determined. Contents of all of the tanks from each heifer and steer were thoroughly mixed, and a 50-mL sample was obtained and was stored at −20 °C for further laboratory analyses.

Allantoin, creatinine, and uric acid were analyzed using a HPLC (Agilent 1100 series, Agilent Technologies, Waldbronn, Germany) as described previously by Czauderna and Kowalczyk (2000), with modifications by George et al. (2006). Total excretion of purine derivatives, calculated as the sum of allantoin and uric acid, was expressed in millimoles per day. Absorbed purines (X, in millimoles per day) were calculated from the excretion of purine derivatives (Y, in millimoles per day) by using the following equation: $Y = (X - (0.30 \times BW^{0.75}))/0.80$, where 0.80 was assumed as the recovery of purines absorbed as purine derivatives while