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Research paper

Effects of different supplements on performance of steers grazing Mombaça guineagrass (*Megathyrsus maximus*) during the dry period

*Efectos de diferentes suplementos en el rendimiento de novillos que pastorean guinea Mombasa (*Megathyrsus maximus*) durante el período seco*

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Abstract

To mitigate the low animal performance on Mombaça guineagrass pasture during the dry period, feeding 2 types of supplement to 2 genetic groups was evaluated. The experimental design was a randomized block design following a 2 × 2 factorial arrangement with 4 replications. The treatments consisted of feeding 2 levels of supplement (0.25 and 1.0% of body weight; BW), named low-cost supplement (LCS; US$ 11.75/steer) and high-cost supplement (HCS; US$ 62.80/steer), respectively, for 130 days (July–October; dry season) to 2 genetic groups: Caracu and F1 Senepol × Caracu. The steers were supplemented daily and weighed every 28 days. Pastures were evaluated monthly to estimate the herbage accumulation rate, herbage mass (HM), leaf, stem and dead material percentages and nutritive value. HM, morphological components and nutritive value were independent of supplement type fed (P>0.05). There were decreases in HM (3,720 to 3,205 kg DM/ha), daily herbage allowance (14.0 to 9.4 kg DM/100 kg BW) and leaf percentage (33.4 to 21.2%) and increase in dead material percentage (53.3 to 67.7%) throughout the experimental period. In vitro organic matter digestibility (59.9%), crude protein concentration (10.0%), neutral detergent fiber (72.1%) and acid detergent lignin (2.9%) remained constant from July to September but increased markedly in October. Steers supplemented with HCS performed better (P<0.05) than those which received LCS (1.005 vs. 0.565 kg liveweight gain/head/day, respectively). Regardless of supplement type, F1 Senepol × Caracu steers had greater average daily gains than pure Caracu steers (0.88 vs. 0.71 kg/hd/d, respectively). Feeding HCS to steers in the dry season would produce better performance than LCS and could reduce time to reach slaughter weight but weight changes during the subsequent wet season should be monitored to assess the extent of any compensatory gain by the low-cost group during this period to reduce the weight advantage of the high-cost group.

Keywords: *Bos taurus*, guineagrass, herbage allowance, nutritive value.

Resumen

Para mitigar el bajo rendimiento animal en pasto guinea Mombasa durante el período seco, se evaluaron dos tipos de suplementación y dos grupos genéticos. El diseño experimental fue de bloques al azar con un arreglo factorial de 2x2 con cuatro repeticiones. Los tratamientos consistieron en dos niveles de suplementos (0.25% y 1.0% del peso vivo; BW) denominados suplemento de bajo costo (SBC; US$ 11.75/novillo) y suplemento de alto costo (SAC; US$ 62,80/novillo), ofrecidos por 130 días entre julio y octubre (período seco) a dos grupos genéticos: Caracu y F1 Senepol × Caracu. Los novillos se suplementaron diariamente y se pesaron cada 28 días. Se evaluaron los pastos mensualmente para estimar la tasa de acumulación de pasto, la masa del forraje (HM), los porcentajes de hojas, tallos y material muerto y el valor nutritivo. La

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HM, los componentes morfológicos y el valor nutritivo no difirieron (P>0.05) entre los animales que recibieron uno u otro suplemento. Hubo disminuciones en la HM (3,720 a 3,205 kg/ha), la cantidad diaria de pasto (14.0 a 9.4 kg DM/100 kg de peso vivo) y el porcentaje de hojas (33.4 a 21.2%) y un aumento del porcentaje de material muerto (53.3 a 67.7%) a lo largo del período experimental. No hubo diferencias para la digestibilidad in vitro de la materia orgánica (59.9%); concentración de proteína cruda (10.0%), fibra detergente neutra (72.1%) y lignina detergente ácida (2.9%) de julio a septiembre, pero aumentó notablemente en octubre. Los novillos suplementados con SAC se desempeñaron mejor (P<0.05) que los que recibieron SBC (la media fue de 1.005 y 0.565 kg/novillo/día, respectivamente). Independientemente del suplemento, los novillos F1 Senepol × Caracu (0.880 kg/día) tuvieron una ganancia diaria promedio mayor que los novillos Caracu puros (0.710 kg/día). El uso de dietas SAC durante el período seco produce mejores resultados que SBC, y reduce el tiempo para alcanzar el peso de beneficio, pero debe monitorearse las ganancias de peso durante la estación lluviosa subsiguiente, para ver la magnitud de crecimiento compensatorio en el grupo SBC durante este período para ver si es psoible reducir la ventaja del grupo SAC.

Palabras clave: *Bos taurus*, disponibilidad de forraje, Mombaça, valor nutritivo.

Introduction

Sustainable technological advances to improve the quality of beef are required if Brazil aims to maintain its position as one of the most important players in the world beef market. Meat tenderness is, directly or indirectly, the organoleptic characteristic consumers value most (Mendes et al. 2012) and slaughter age plays an important role, since younger animals tend to produce more tender meat (Alves et al. 2005).

However, seasonality of forage production of tropical pastures remains a major constraint in having animals reach acceptable slaughter weights when still young. This seasonality is characterized by marked reductions in forage quantity and quality during the dry season, with concomitant decrease in animal performance and increase in age at slaughter. Achieving acceptable slaughter weights at a young age requires high animal performance throughout the year.

To address the issue of improving dry season performance, Euclides and Medeiros (2005) built a database from results of studies published in Brazil that investigated protein and energy supplementation of livestock during the dry season. Analysis of data on liveweight gains and feed conversion efficiency led the authors to suggest that modest supplementation contributed to the economic improvement of production systems, not only by lowering costs, but also by increasing the efficiency of inputs, particularly by maximizing the use of pasture. For this reason, feeding a modest amount of supplement during the dry period is quite common in Brazilian production systems. In general, supplements fed include a combination of non-protein nitrogen and a natural protein source, are reasonably palatable and provide discrete nutrients that are limiting in the available pasture.

In this context, Araújo (2014) reported that steers fed a protein supplement at 0.16% of body weight (BW) while grazing *Megathyrsus maximus* cv. Mombaça (Mombaça guineagrass) pasture produced higher average daily gain (ADG) than unsupplemented steers (460 vs. 250 g/hd/d, respectively). However, steers managed under this supplementation strategy failed to reach desirable slaughter weight (480–500 kg) at 18 months of age as dry season gains in excess of 800 g/hd/d are needed. The combination of a better quality supplement (energy plus protein) and animals with superior genetic makeup could possibly achieve the target (Menezes and Restle 2005; Perotto et al. 2009).

Our objective was to test this hypothesis by evaluating the effects on growth rates of steers of feeding low- and high-cost supplements to 2 groups of steers with different genetic potential, while grazing Mombaça guineagrass pastures during the dry season, in the Brazilian Cerrado.

Material and Methods

The experiment was carried out at Embrapa Beef Cattle, Campo Grande, MS, Brazil (20°27' S, 54º37' W; 530 masl), over 130 days from 15 July to 23 October 2014. To allow the rumens of steers to become adapted to the various supplements, supplements were introduced gradually during the first 15 days as follows: 1/3 of the desired supplement level was offered during the first week, rising to 2/3 of the desired level in the second week, with the full amount offered from the fifteenth day on. The climate of the region is classified (Köppen) as Tropical Savanna (AW), with well-defined wet (November–April) and dry (May–October) seasons. Monthly rainfall, average relative humidity and minimum, medium and maximum temperatures (Figure 1) were recorded at a meteorological station, located about 3 km from the experimental area.

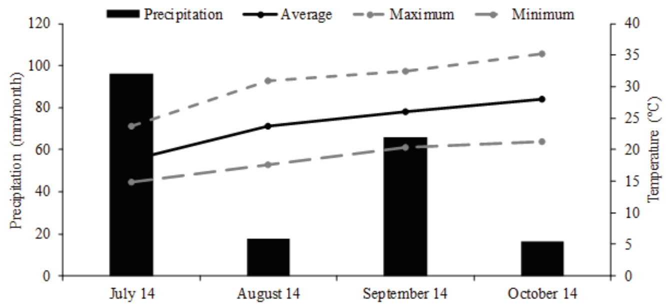

Figure 1. Precipitation and average, minimum and maximum temperatures during the experimental period at Campo Grande, MS, Brazil.

The experimental area of 12 ha was divided into 4 blocks, and each block was divided into two 1.5 ha paddocks. Mombaça guineagrass was established in 2008 and since then had been grazed continuously and fertilized annually. The soil is classified as a clayey dystrophic Red Latosol (FAO 2009). During the rainy period prior to the beginning of the experiment, the pastures were fertilized with 18 kg P, 33 kg K and 150 kg N/ha and were rotationally stocked with a post-grazing sward height of 50 cm. During the experimental period, pastures were continuously grazed at a fixed stocking rate, i.e. number of animals per ha.

The experimental design was a randomized block design following a 2 × 2 factorial arrangement with 4 replications. The treatments consisted of 2 supplementation regimes (low- and high-cost) and 2 genetic groups. The low-cost supplement (LCS or Control, which is widely used in the beef production systems in the region) was formulated to allow the diet (forage plus supplement) to reach 13% crude protein and to meet recommended mineral requirements (Table 1), and was fed at 0.25% of body weight (BW) aimed at achieving weight gains of 500 g/hd/d. The high-cost supplement (HCS) was formulated to allow a daily gain of 1 kg/hd/d (NRC 1996; Table 1) and was fed at 1.0% of BW. Supplements were provided daily at 8:00 h, with the amount adjusted each time animals were weighed. Refusals were weighed daily and daily supplement intake was measured as the difference between supplied feed and refusals in the trough.

The genetic groups were Caracu and F1 Senepol × Caracu. Thirty-two steers (16 from each genetic group), approximately 9-months-old and with mean initial body weight of 240 ± 12 kg, were used. The steers were distributed according to genetic group (2 Caracu and 2 F1) and body weight so that the average body weights of the 4 steers in all paddocks were similar. All paddocks were provided with concrete water troughs and plastic troughs for supplements. The experimental unit was the paddock and steers were the observation unit.

All steers were weighed every 28 days, following a 16-h fast from feed and water. Average daily gain (ADG) was calculated as the change in body weights of steers divided by the number of days between weighings.

Table 1. Ingredients and nutrient composition of supplements fed to steers grazing Mombaça during the dry season.

	Percentage (as fed)	
Ingredient	Low-cost	High-cost
Soybean	0.0	30.0
Soybean meal	28.0	31.6
Urea	8.0	0.0
Ground corn	52.0	13.7
Soybean hulls	0.0	16.0
Mineral mix[1]	7.0	8.7
Sodium chloride	5.0	0.0
Nutrient	Percentage (DM basis)	
Crude protein	42.8	30.7
Ash	18.1	14.5
Total digestible nutrients	65.4	72.3
Neutral detergent fiber	9.7	21.1
Ether extract	3.9	9.0

[1]Composition: crude protein – 460 g/kg; non-protein nitrogen – 420 g/kg; Calcium – 40 g/kg; Phosphorus – 30 g/kg; Sulphur – 19.5 g/kg; Magnesium – 8,000 mg/kg; Sodium – 61 g/kg; Cobalt – 30 mg/kg; Copper – 400 mg/kg; Chromium – 10 mg/kg; Iron – 500 mg/kg; Iodine – 30 mg/kg; Manganese – 1,050 mg/kg; Selenium – 10 mg/kg; Zinc – 2,700 mg/kg; Fluorine – 300 mg/kg.

Sward height was measured at 40 random points per paddock every 28 days using a graduated rule. The height recorded was the mean height of the sward around the rule. Simultaneously, nine 1 m^2 forage samples were cut at close to ground level in each paddock to estimate herbage mass (HM). The samples were divided into 2 sub-samples: 1 sub-sample was oven-dried at 65 ºC to constant weight to determine DM yield, while the other was grouped (composite of 3 sub-samples) and separated into leaf (leaf blade), stem (stem and sheath) and dead material. Each component was oven-dried at 65 ºC and weighed to estimate the proportion of each component.

Two hand-plucked samples were taken from each paddock on each sampling date. The samples were oven-dried at 55 ºC, ground to pass a 1-mm mesh sieve and analyzed for crude protein (CP), ash-free neutral detergent fiber (NDF), acid detergent lignin (ADL) and in vitro organic matter digestibility (IVOMD) via near-infrared reflectance spectrophotometry (NIRS), according to Marten et al. (1985).

To estimate forage accumulation, an area of 0.25 ha was excluded from grazing in all paddocks (1.5 ha), so the grazing area per paddock was reduced to 1.25 ha. On Days 1 and 28, this area (0.25 ha) was sampled to estimate forage mass and proportions of morphological components following the same methodology as described above. Each grazing period started on Day 28, at which time a new area of 0.25 ha was excluded from grazing and sampled after 28 days, with the process being repeated every 28 days. Forage accumulation was calculated as the difference between forage mass recorded on Days 1 and 28, and only the green components (leaves and stems) were considered. Herbage allowance (Allen et al. 2011) was calculated by dividing mean herbage mass by the mean total body weight in each paddock, and the result was divided by the number of days between samples.

Statistical analysis of all pasture-related variables was performed using the mathematical model containing the random effect of blocks and the fixed effects of supplement, genetic group, month and interactions between them. ADG data were analyzed via a multivariate analysis with repeated measures, according to Littell et al. (2000). Data were analyzed using the PROC MIXED in SAS (1996). Akaike's information criterion was used to choose the best covariance structure (Wolfinger 1993). Means were compared with Tukey's test (P<0.05).

Results

Forage mass, morphological components and nutritive value were not significantly (P>0.05) affected by type of supplement fed (data not shown). However there were variations in pasture characteristics throughout the experimental period (Table 2). Herbage accumulation rate in October was greater than those in other months. Canopy height in July was higher than that in October. Herbage mass and daily herbage allowance were greater during July and August than in September and October (Table 2).

Leaf percentage was greater in July than in other months, while that in August was greater than that in September. Stem percentage was lower during October than in the other months, while percentage of dead material was lower in July than in the other months (Table 2).

In vitro organic matter digestibility and crude protein concentration were similar from July to September (P>0.05), but lower (P<0.05) than those observed in October. While acid detergent lignin concentration was higher in July–September than in October (Table 2), no differences in neutral detergent fiber concentration were

Table 2. Means, standard error of the mean (s.e.m.) and probability levels (P) for herbage accumulation rate, canopy height, herbage mass, herbage allowance and percentages of leaf, stem and dead material in standing forage and in vitro organic matter digestibility and crude protein and acid detergent lignin concentrations in plucked samples of Mombaça guineagrass pastures during the dry season.

Variable	July	August	September	October	s.e.m.	P
Herbage accumulation rate (kg/ha/day)	7.5b	-9.8b	-8.9b	38.5a	6.51	0.0001
Canopy height (cm)	47.0a	44.0ab	41.0ab	37.0b	1.40	0.0009
Herbage mass (kg/ha DM)	3,720a	3,625a	3,250b	3,205b	136.0	0.0180
Daily herbage allowance (kg DM/100 kg BW)	14.0a	12.3a	10.3b	9.4b	0.77	0.0001
Leaf (%)	33.4a	23.9b	19.2c	21.2bc	1.80	0.0018
Stem (%)	13.2a	13.5a	12.1a	10.9b	0.90	0.0020
Dead material (%)	53.3b	62.5a	68.6a	67.7a	1.70	0.0001
In vitro organic matter digestibility (%)	60.0b	58.2b	61.5b	65.9a	1.40	0.0001
Crude protein (%)	10.0b	10.5b	9.6b	15.7a	0.45	0.0001
Acid detergent lignin (%)	2.9a	2.9a	2.9a	2.4b	0.10	0.0001

Means within rows followed by different letters differ by Tukey's test (P<0.05).

observed between months during the experimental period (P>0.05) and the mean (± standard error) value was 72.1 ± 0.8%.

An interaction between the effects of supplement type and experimental month (P=0.0001) was observed for average daily gain (ADG). While ADG for steers fed LCS was greater (P<0.05) during September-October than during August-September, ADG for steers fed HCS did not differ throughout the study (P>0.05). Steers fed HCS achieved higher ADG throughout the study than those fed LCS but differences were significant only during July–September (Table 3).

Table 3. Means and standard error of the mean (s.e.m.) for average daily gain of steers receiving 2 supplement types on Mombaça guineagrass pasture during the dry season.

Period/Supplement type	Average daily gain (kg/steer)	
	Low-cost	High-cost
July-August	0.577ABb	0.973Aa
August-September	0.387Bb	1.093Aa
September-October	0.730Aa	0.941Aa
Mean	0.565	1.005
s.e.m.	0.054	0.051

Means followed by different lower-case letters within rows and different upper-case letters within columns differ by Tukey's test (P<0.05).

There was no interaction between supplement type and genetic group (P=0.3093) for ADG, but there was a difference between genetic groups (P=0.001). Regardless of supplement type, F1 Senepol × Caracu steers had greater ADG than pure Caracu steers (0.880 ± 0.29 vs. 0.710 ± 0.30 kg/hd/d). At the end of the experimental period, crossbred steers had gained 13 and 15 kg more than purebred steers (Table 4), when supplemented with LCS and HCS, respectively. Supplement intake and supplement cost per animal according to treatment are presented in Table 4.

Table 4. Means for initial and final body weight and bodyweight gain of steers of 2 different breeds receiving 2 supplement types on Mombaça guineagrass pasture during the dry season, supplement intake and supplement cost.

	Low-cost		High-cost	
	F1[1]	Caracu	F1	Caracu
Initial final body (kg)	239	235	243	242
Final final body (kg)	295	278	339	323
Bodyweight gain (kg/steer)	56	43	96	81
Supplement intake (kg/steer)	54.6	52.4	236.1	228.9
Supplement cost (US$/kg)	0.22		0.27	
Supplement cost (US$/steer)	12.01	11.53	63.74	61.80

[1]F1 Senepol × Caracu

Discussion

As daily herbage allowance (DHA), morphological components and nutritive value did not vary between the pastures in which the animals received one or the other supplement (LCS or HCS), the differences in animal weight gain were a result of the supplements consumed.

The average stocking rates observed in this study were 1.6 and 2.0 AU/ha for LCS and HCS supplements, respectively. As the number of animals remained the same on each treatment throughout, the observed differences and changes in stocking rate were a consequence of increases in BW over time and the differences in ADGs for steers consuming the 2 supplements (Table 3). Araújo (2014) observed that, when Mombaça guineagrass was managed to leave a 45 cm post-grazing residue, herbage mass remaining from the previous wet season was sufficient to maintain a mean stocking rate varying between 1.4 and 1.8 AU/ha (AU = 450 kg body weight) during the dry season. The stocking rates maintained during the dry period in the current work confirm these earlier observations.

The lack of herbage accumulation from July to September (Table 2) is typical of pasture production in tropical regions and results from rainfall seasonality (Figure 1), in addition to temperature variations and photoperiod. This lack of pasture growth was compounded by a reduction in leaf percentage in available forage and an increase in dead material (Table 2), which were related to low leaf accumulation and natural plant senescence, which was accelerated by water stress during the dry season (Figure 1) and by grazing, since animals preferentially select leaves (Brâncio et al. 2003; Trindade et al. 2007).

Since animal numbers were fixed and animals gained weight, decreases in DHA were also observed (Table 2); however, even at the end of the dry season, the DHA was 9.4 kg herbage DM per 100 kg BW. Hodgson (1990) suggested that DHA should be 10–12% to maximize herbage consumption. It is clear that herbage mass was not a limiting factor for forage intake by the animals. For supplementation of animals on pasture using nitrogen (N)-based supplements it is necessary to ensure that adequate pasture is available to allow steers to increase feed intake.

Despite higher grazing pressure on the HCS treatment, ADG for HCS steers was greater than for LCS steers (Table 3). This difference is a reflection of the greater quantity of supplement fed to the HCS group combined with the higher total digestible nutrient (TDN) concentration and the difference in the N ingredients. The N component of the LCS was largely non-protein nitrogen, while that in HCS was totally plant protein, which could be expected to contain a significant percentage of by-pass protein. The greater performance of animals in this study relative to those of Araújo (2014) for animals grazing Mombaça guineagrass pasture and supplemented with similar supplements might be attributed to lesser amounts of supplement ingested in that study. Those authors registered 0.46 and 0.77 kg/steer/d for animals supplemented with LCS at 0.15% BW and HCS at 0.6% BW, respectively.

We chose the LCS based on the ADG (500 g/hd/d) achieved by supplemented steers grazing Mombaça guineagrass during the dry period in the work by Euclides et al. (2008), indicating that feeding this form of supplement at that level was effective in correcting nutrient deficiency on these pastures during the dry season.

Regarding the nutritive value of forage, there were no differences in IVOMD, CP, NDF and ADL concentrations in plucked forage samples from July to September (Table 2), the means being 59.9, 10.0, 72.1 and 2.9%, respectively. Relatively high nutritive value during the dry season is a characteristic of *Megathyrsus maximus* (syn. *Panicum maximum*) cultivars (Euclides et al. 2008; Santana et al. 2013; Araújo 2014), especially when comparing them with *Urochloa brizantha* (syn. *Brachiaria brizantha*) or *U. decumbens* during the same period (Euclides et al. 2007a, 2007b, 2009; Garcia et al. 2014).

Since there was no significant difference in nutritive value of plucked samples from July to September, the lowest leaf:dead material ratio in September (Table 2) is the probable cause of the reduction in ADG during August-September in the LCS group (Table 3). According to Gontijo Neto et al. (2006), the presence of dead material in a sward can act as a physical barrier to leaf selection and ease of harvest by cattle, resulting in decreased herbage intake and, consequently, animal performance. On the other hand, the weight gain of steers receiving HCS supplement was not reduced during this period (Table 3), suggesting that the intake of approximately 2.5 kg of supplement per day (78.3% TDN and 31.0% CP) was sufficient to compensate for reduced herbage availability.

The increase in herbage accumulation rate (HAR) between September and October (Table 2) can be explained by a temperature increase and precipitation of 82.3 mm during these months (Figure 1), which was sufficient to restore the moisture levels in the soil. As a result of the increased plant growth, there were increases in the percentages of CP and IVDOM and decrease in ADL concentration in green forage produced (Table 2). On the other hand, herbage mass and morphological structure of the pasture in October (Table 2) did not reflect the high HAR. Through selection and ingestion of new growth by animals there was a marked increase in BW gain of the animals receiving LCS supplement as a response to the greater nutritive value of herbage in October.

The superior weight gains of F1 Senepol × Caracu steers relative to Caracu steers would be a result of heterosis, as F1 animals regularly outperform their purebred parents.

The additional 40 kg of BW in steers receiving the high-cost supplement should reduce the age at which animals reach slaughter weight. If these steers were kept on Mombaça grass pasture during the subsequent rainy period, they should reach slaughter weight (480–500 kg) at the end of the wet season when they would be 18 months old. This assumption was based on ADG of, approximately, 800 g/hd/d during the wet season (November–May) observed by Euclides et al. (2017) and Alvarenga et al. (2020) on Mombaça guineagrass pastures. Additionally, the F1 Senepol × Caracu steers supplemented with HCS would take 20 days less to reach slaughter weight than Caracu steers (Table 4). Thus, the use of F1 crossbreed steers provides an option for capitalizing on the diet improvement provided by HCS by either further reducing time to slaughter or increasing weight at slaughter.

On the other hand, the steers receiving LCS would not reach slaughter weight during the subsequent rainy season. They would need another 2–4 months in the next dry season, depending on the supplement provided, to reach slaughter weight. These assumptions would depend on whether or not these animals could express compensatory growth during the wet season relative to the HCS group (Barbosa et al. 2016). Thus, the additional cost of supplementing steers with HCS (Table 4) may be offset by the financial benefits of earlier slaughter plus the release of pasture for feeding other animals during the subsequent dry season, when this resource is very limited, or heavier slaughter weight if retained longer.

Conclusions

These data indicate that steers can gain 0.5 kg/d during the dry season, when grazing Mombaça guineagrass pasture and receiving a standard concentrate supplement at a rate of 0.25% BW. Alternatively, steers receiving a more-costly concentrate supplement with protein based on plants, at a rate of 1% BW, can gain 1 kg/d throughout the dry season, resulting in target slaughter weight being reached at a younger age. This can result in financial benefits which need to be assessed. Regardless of the supplement provided, F1 Senepol × Caracu steers made superior gains to pure Caracu steers. Thus, in order to increase the overall efficiency of the grazing system this breed cross could be recommended for the Brazilian Cerrado. Further studies to determine performance of stabilized crossbreds or composite breeds would establish if some of the benefits from the F1 crosses are lost with subsequent crossing. Our study was performed only during the dry season, and longer-term studies to include the subsequent wet and dry seasons are needed to confirm whether the observed differences in mean body weight of the 2 groups at the end of the feeding period could be maintained during the subsequent wet season and up to slaughter.

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