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ANIMAL SCIENCE

Nutritional and productive performance of purebred Nellore heifers and crossed with Brangus and Braford finished in a feedlot system

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Abstract: This study evaluated the nutritional and productive performance of Nellore purebred heifers and crossbred Brangus x Nellore (BGNE) and Braford x Nellore (BFNE) in a feedlot system. Thirty heifers (10 of each genetic group) with an average age of 18 months and an initial body weight of 261 kg were used. The experiment was structured and conducted according to a completely randomized design, with three treatments. Heifers received two diets (60 days each) during the experimental period. The experiment lasted 120 days with four experimental periods. Nellore heifers had a lower intake than crossbred heifers ($P < 0.05$). There were no differences between BGNE and BFNE heifers, which had higher final body weight, average daily gain, feed efficiency, hot carcass weight and carcass length than NE heifers. Crossed heifers presented better fat cover than NE heifers. However, NE heifers had higher carcass dressing Despite presenting lower carcass yields than Nellore heifers, crossed heifers are more efficient and have higher performance and better fat cover on the carcass than purebred Nellore heifers. Crossbreeding synthetic breeds, such as Brangus and Braford breeds, with the Nellore breed is an effective way to increase the productivity and efficiency of feedlot heifers in tropical regions.

Key words: *Bos taurus indicus*, *Bos taurus taurus*, carcass, feed efficiency, intake.

INTRODUCTION

Bos indicus presents high representativeness in the global cattle herd, since more than half of the cattle in the world are raised in tropical environments (Cundiff et al. 2012) and the Nellore (NE - *Bos indicus*) represents 80% of the Brazilian herd (Oliveira & Millen 2014). The use of crossbred animals has been an alternative to increase animal performance and reduce the feedlot period, and the NE breed also plays a key role in providing heterosis (Amaral et al. 2018).

Crossbred animals exposed to high-quality diets could be an alternative to reduce the feedlot period. Since the genetic composition has an influence on performance, when planned correctly, it can positively influence 20 to 25% of the final productivity of cattle (Pastor et al. 2017). Crossbreeding can be a gainful strategy to improve beef production and profitability (Rezagholivand et al. 2021) both by providing the complementarity between breeds and by the manifestation of heterosis (Guimarães et al. 2022), which leads to improvements in performance, carcass characteristics and productivity (Amaral et al. 2018). However, *Bos indicus* cattle differ from *Bos taurus* in feed intake, growth rate and body composition (Lunstra & Cundiff 2003, Schutt et al. 2009). These possible differences imply differences in the use of nutrients, which are supported by different requirement systems, such as BR-CORTE (Valadares Filho et al. 2016) and NASEM (2016).

The use of crosses between *Bos taurus* and *Bos indicus* has boosted cattle production in tropical areas, primarily through the utilization of Aberdeen Angus (Santiago et al. 2021). Research has shown significant differences in the nutritional efficiency and carcass characteristics between different genetic groups of beef cattle (Goulart et al. 2020). However, there is little information on Brangus and Braford animals crossed with NE.

Therefore, this study aimed to evaluate the nutritional and productive performance of purebred NE, Brangu x NE (BGNE) and Braford xNE (BFNE) heifers in a feedlot system.

MATERIALS AND METHODS

The research was carried out in accordance with the Ethical Principles in Animal Experimentation, adopted by the National Council for the Control of Animal Experimentation (CONCEA) of Brazil.

Design, experimental procedures and sampling

The experiment was carried out in the experimental feedlot, located in Campos de Júlio city with latitude: 13° 53 ‘58 “S and longitude: 59° 08’ 51” W, in the state of Mato Grosso, from August to November 2016.

Thirty heifers (body weight - BW = 261 kg ± 17.5; 18 months) from three genetic groups - Nellore (NE), Brangus x Nellore (BGNE) and Braford x Nellore (BFNE) - were used. The experiment was structured and conducted according to a completely randomized design, with three treatments (genetic groups) with 10 repetitions each.

The heifers were submitted to a 14-day adaptation period to the feedlot and fed a total mixed diet at 1.8% of BW composed of corn silage and concentrated feed. Then, the heifers were weighed at the beginning of the experiment after being subjected to fasting from solids (12 hours) and randomly allocated to individual pens (15.75 m^2) provided with a feeder and a drinking fountain. The experiment lasted 120 days with four experimental periods.

Heifers received two diets during the experimental period (Table II). In the initial diet (roughage:concentrate ratio, R:C - 40:60), corn silage was used as roughage, and in the second diet (R:C - 30:70), the roughage was *Panicum Hybrid* cv. Massai hay. The animals were fed each diet for 60 days, and in both groups, the commercial concentrate (17.85% CP) from Nutrideal® was used (Table I).

A total mixed ration was provided twice a day (7h00 am and 4h00 pm). The amount of feed was adjusted daily, allowing 5.0% leftovers to guarantee *ad libitum* intake. Leftover was collected and weighed daily, obtaining a sample composed of animal/week. Diet samples were collected every day, and at the end of a week, a sample composed of animals was taken.

Fecal collection was performed for three days (Day 1 - 9h00; Day 2 -13h00 and Day 3 - 16h00) in the last week of each experimental period, obtaining a composed sample per animal per period.

Sample processing and chemical analysis

The samples were dried in a forced air ventilation oven (55 °C) for 72 h and ground (Wiley mill - Tecnal, SP, Brazil) at 2,0 mm to determine the indigestible neutral detergent fiber (iNDF) concentration and 1,0 mm for other analyses. To quantify iNDF, the fecal samples, feeds and leftovers were placed in filter bags (model F57,

Table I. Chemical composition (g/kg of dry matter) of diet ingredient.

Item	Concentrate[a]	Corn silage	Massai hay
Dry matter	870.4	347.5	861.6
Organic matter	923.9	972.8	959.4
Crude protein	178.5	85.3	29.5
Ether extract	44.5	22.7	12.4
Nonfibrous carbohydrates	612.2	277.1	131.6
Neutral detergent fibre (NDF)	114.2	621.0	836.0
NDF corrected for ash and protein	91.7	586.0	785.9
Indigestible NDF	15.4	186.5	318.2

[a]Calcium (min) - 12 g; Cobalt (min) - 2.43 mg; Copper (min) - 37.8 mg; Sulfur (min) - 1400 mg; Ethereal Extract (min) - 30 g; FDA (max) - 40 g; Phosphorus (min) - 4000 mg; Iodine (min) - 3 mg; Magnesium (min) - 1000 mg; Manganese (min) - 27 mg; Fibrous Matter (min) - 90 g; Mineral Matter (min) - 90 g; Salinomycin (min) - 16 mg; Selenium (min) - 0.5 mg; Sodium (min) - 1500 mg; Zinc (min) - 97.2 mg.

Table II. Chemical composition (g/kg DM) of the diets according to the roughage.

Item	Diets[a]	
	Corn silage	Massai hay
Dry matter	661.2	867.8
Organic matter	943.4	934.5
Crude protein	141.2	134.0
Ether extract	35.8	34.9
Nonfibrous carbohydrates	478.2	468.0
Neutral detergent fibre (NDF)	316.9	370.7
NDF corrected for ash and protein	289.4	300
Indigestible NDF	83.8	106.2
Total digestible nutrients	776.1	718.0

[a]According to the BR-CORTE System (Valadares Filho et al., 2016) for 1.0 kg gain per day.

Ankon®) and incubated in a rumen-cannulated animal for 288 h (Valente et al. 2011).

The samples were put in the bags following the ratio of 20 mg DM/cm^2 of surface (Nocek 1988) and were incubated in the rumen of two crossbred Holstein × Zebu steers. After 288 h, the bags were cleaned with tap water and oven-dried (60°C/72 hours and 105°C/1 hour) for posterior analysis. Fecal production (FP) was estimated using indigestible neutral detergent fiber (iNDF) as an internal marker for calculating apparent digestibility.

The samples collected were analyzed for dry matter (DM) and organic matter (OM, method No. 934.01), mineral matter (MM, method No. 924.05) and crude protein (CP, method No. 920.87) according to AOAC (2000) and ether extract (EE) determined by method No. 920.85 (AOAC 1990).

The neutral detergent fiber (NDF) content was estimated according to Mertens (2002) without the addition of sodium sulphite using thermostable alpha-amylase in the detergent. The NDF was corrected to ash (Mertens 2002) and protein (Licitra et al. 1996). Nonfiber carbohydrates (NFC) were calculated according to Detmann & Valadares Filho (2010). The contents of total digestible nutrients (TDN) were calculated according to the NRC (2001).

Productive performance and carcass traits

Heifers were weighed (after being subjected to fasting from solids -12 hours) to obtain final BW and average daily gain (ADG). The feed efficiency (FE) was estimated by the ratio between ADG (kg) and DM intake. The animals were slaughtered in a commercial slaughterhouse (Diamantino, Mato Grosso State) following the procedures of Brazilian standards (Ludtke et al. 2012). Fat cover was subjectively evaluated according to the scale used by the packing plant where the animals were slaughtered by the same evaluators. The carcasses were classified on a scale of 1 to 5: 1 = absent fat, 2 = sparse fat (1 to 3 mm), 3 = medium fat (above 3 to 6 mm), 4 = uniform fat (over 6 to 10 mm), and 5 = excessive fat (over 10 mm).

The carcass dressing (CD - %) was calculated through the ratio between hot carcass weight (HCW) and the final body weight (FBW). The HCW was obtained by the sum of the half-carcasses after slaughter and evisceration. After 48 hours of cooling in a cold chamber, measurements of carcass length (CL) and carcass thoracic depth (CTD) were performed. The CL was measured using a measuring tape from the cranial border of the middle portion of the first rib to the cranial border of the pubic bone (Boggs & Merkel 1984), and the CTD was measured from the ventral base of the 5th rib (sternum bone) to the ventral base of the vertebral foramen of the 5th thoracic vertebra.

Statistical analysis

Comparisons between treatment averages were performed using the following orthogonal contrasts: Nellore *versus* crossbred heifers (BGNE and BFNE) and BGNE *versus* BFNE. The initial BW was used as a covariate to adjust the other variables analyzed. The data were analyzed using the PROC MIXED procedure of the SAS statistical package, version 9.0, using the following statistical model:

$$Y_{ij} = \mu + ti + \beta\,(\bar{x}_{ij} - x_{ij}) + e_{ij}$$

where Yij = experimental response measured in the experimental unit already submitted to treatment i; μ = general constant; ti = effect related to treatment i; β = linear regression coefficient between the covariate (Xij) and response variable (Y); and eij = random error associated with each observation. The Kruskal–Wallis nonparametric test was performed to evaluate the means for finishing the fat in the carcass. For all procedures, a significance level of 5% was adopted.

RESULTS

Intake and digestibility

Nellore heifers had a lower intake of dietary constituents than crossbred heifers (P <0.05). BGNE heifers presented higher NDFcp intake (P<0.05) than BFNE heifers (Table III).
Except for the higher NDFap digestibility (P <0.05) observed in BGNE than BFNE heifers, there was no difference (P> 0.05) among the genetic groups for the apparent digestibility of nutrients and for the dietary concentration of TDN (Table III).

Productive performance and carcass traits

There were no differences between BGNE and BFNE heifers (P>0.05), which had higher FBW, ADG, FE, HCW and CL than NE heifers. However, NE heifers had higher CD (P>0.05) (Table IV). There was no difference in CTD between NE and crossbred heifers (P>0.05). Crossed heifers presented better fat cover (P<0.05) than NE heifers (Table V).

Table III. Intake and total apparent digestibility and dietary concentration of total digestible nutrients (TDN) according to genetic group.

Item[b]	Genetic group[a]			e.p.m[c]	Contrasts			
					NE x Crossbred		BGNE x BFNE	
	NE	BGNE	BFNE		Estimate	P value	Estimate	P value
Intake								
DM	7.59	9.45	8.87	0.08	-3.19	0.001	0.46	0.342
OM	6.67	8.16	7.82	0.09	-3.29	<0.001	0.83	0.053
CP	0.96	1.28	1.14	0.07	-0.52	<0.001	0.12	0.063
EE	0.26	0.33	0.31	0.06	-0.12	0.001	0.02	0.270
NDFcp	2.08	2.66	2.29	0.04	-0.80	0.009	0.35	0.014
TDN	5.78	7.19	6.50	0.10	-2.15	0.006	0.67	0.051
	g/kg of body weight							
DM	23.00	26.98	26.47	1.09	-7.19	0.001	1.07	0.408
NDFap	6.76	8.07	7.31	0.76	-1.77	0.006	0.93	0.018
Digestibility (g/g)								
DM	0.75	0.75	0.73	0.15	2.92	0.199	1.99	0.141
OM	0.78	0.77	0.75	0.14	3.55	0.087	1.44	0.219
CP	0.76	0.76	0.76	0.16	-0.71	0.756	0.37	0.785
EE	0.86	0.84	0.84	0.15	2.64	0.267	0.42	0.764
NDFap	0.69	0.69	0.66	0.12	1.48	0.198	2.56	0.001
Dietary concentration (g/g)								
TDN	0.76	0.75	0.75	0.11	3.92	0.328	-1.00	0.668

[a]NE. Nellore. BGNE. Brangus-Nellore and BFNE. Braford-Nellore; [b]DM. dry matter; OM. organic matter; CP. crude protein; EE. ether extract; NDFap. neutral detergent-soluble fibre corrected for ash and protein; TDN. total digestible nutrients; [c]e.p.m. standard error of the mean.

Table IV. Productive performance and quantitative characteristics of the carcass according to the genetic group.

Item	Genetic group[a]			e.p.m[b]	Contrasts			
					NE x Crossbred		BGNE x BFNE	
	NE	BGNE	BFNE		Estimate	P value	Estimate	P value
Average daily gain (kg/day)	0.76	1.14	1.09	0.04	-0.65	<0.001	0.11	0.205
Final body weight (kg)	344.10	385.40	382.01	5.36	-68.6	<0.001	11.53	0.203
Feed efficiency (kg)	0.11	0.13	0.13	0.01	-0.03	0.001	0.01	0.527
Carcass								
Hot weight (kg)	181	198.45	195.5	2.43	-25.99	0.001	7.88	0.077
Yield (%)	52.65	51.52	51.19	0.27	2.74	0.017	0.54	0.403
Length (cm)	122.40	127.10	126.56	0.77	-9.49	0.002	-0.25	0.883
Thoracic depth (cm)	42.50	41.30	42.56	0.36	1.04	0.502	-1.38	0.154

[a]NE. Nellore. BGNE. Brangus-Nellore and BFNE. Braford-Nellore; [b]e.p.m. standard error of the mean.

Table V. Fat cover of carcasses according to the genetic group.

Item	Fat cover			
	Minimum	Average	Maximum	
Nellore	2.0[b]	2.8[b]	4.1	P value 0.03
Brangus x Nellore	3.0[a]	3.4[a]	4.0	
Braford x Nellore	3.2[a]	3.3[a]	4.1	

Different letters in the column differ by the Kruskal-Wallis test (P <0.05).

DISCUSSION

Crossbred heifers (BGNE and BFNE) presented higher intake, performance and feed efficiency than purebred NE heifers. Regarding carcass traits, except for CD (higher for NE heifers), crossbred heifers presented higher HCW and better fate cover.

Adjustments to predict the DM intake for different breeds of beef cattle were proposed by the AFRC (1993) system with higher DM intake for *Bos taurus* cattle. In addition, the BR-CORTE nutritional requirement system (Valadares Filho et al. 2016) also predicts a higher DM intake for crossbred animals than for Nellore cattle. This difference would be associated with the higher genetic potential for the growth of *Bos taurus* cattle (NASEM 2016).

In fact, it was observed that crossbred heifers had a higher DM and TDN intake, with consequently higher ADG and FE than NE heifers. Crossbred heifers consumed (DM) 20.7% more than NE heifers and were 18.2% more efficient (EF) with performance (ADG) 46.7% higher. These positive results for crossbred heifers can be attributed to heterosis and breed complementarity, resulting in genetic gains. According to Marcondes et al. (2011), it is possible that the higher EF of crossbred animals is associated not only because they have *Bos taurus* blood composition but also since they have higher ADG, energy expenditure with maintenance is diluted and thus makes them more efficient.

According to Habib et al. (2008), the difference in DM intake between subspecies seems to be dependent on the diet, with intake becoming less similar in diets with a high proportion of concentrate. Chemostatic effects are related to the adjustment of DM intake to keep energy intake constant (Krehbiel et al. 2006). In diets with high energy and lower fiber content, ruminants will regulate DM intake by meeting their energy requirement (Mertens 1994), with a consequent balance occurring with the other nutrients.

The net energy requirement for maintenance (NEm) is one of the most important factors for DM intake; thus, the lower TDN intake observed in NE heifers can also be associated with lower nutritional requirements than crossbred heifers. According to the NASEM (2016), NEm would be 10% lower in *Bos indicus* (except Nellore) than in *Bos taurus* and considers that crossbred cattle (*Bos taurus* × *Bos indicus*) have intermediate NEm between purebred breeds. This lower NEm for *Bos indicus* cattle is partly due to the lower weight of internal organs, mainly the gastrointestinal tract (GIT - high metabolic rates) (Menezes et al. 2005), which also contributes to the lower DM intake than that of crossbred animals (Ferrell & Jenkins 1998).

It is known that the amount of DM consumed is related to meeting the animal's energy needs. According to Nascimento et al. (2021), as the diet energy concentration increases, the animals consume more energy per unit of metabolic weight, which also justifies the lower DM intake by Nellore heifers, since they had lower final BW.

This lower GIT weight also partly explains the higher CD of NE heifers. Zebu animals have the genetic characteristic of having a higher CD when compared to *Bos taurus* animals (Rubiano et al. 2009). Furthermore, they present thinner bones, thin leather and less head weight (Façanha et al. 2014). Putrino et al. (2006), evaluating the CD of NE and Brangus, also found a higher CD for NE cattle.

In addition to the nonadditive (heterosis) and additive (breed complementary) effects, the higher ADG and HCW of crossbred heifers can be attributed to the higher CP and TDN intake that allowed the expression of genetic potential. According to Amaral et al. (2018), the higher ADG of crossbred animals is also related to a greater carcass gain with higher amounts of protein and fat retained in the animals' bodies. In fact, it was found that in addition to the higher ADG, crossbred heifers had a higher fat cover than NE heifers.

Genetics is a factor that influences the characteristics of growth and deposition of fat due to the different characteristics of each genetic group that are caused by the maturity of the breed (Lopes et al. 2012). In this way, crossbred heifers reach maturity earlier and present higher deposition of fat on carcasses. Barwick et al. (2009) related the deposition of fat according to the origin of the breeds, considering the evolutionary differences and adaptations to the environments in which they were inserted.

The CL (Pacheco et al. 2014) and CTD (Mourão et al. 2010) show a positive correlation with carcass weight and are metric characteristics more influenced by genetic additive racial and heterotic effects. Thus, crossbred animals tend to grow earlier than NE animals and have greater longitudinal growth (Machado et al. 2014).

BGNE and BFNE heifers have the same proportion of *Bos Taurus* blood composition (British taurine breed - Hereford and Angus). Thus, considering that the same diet was offered, the same DM and GE intake observed may be associated with the same maintenance and production needs of heifers. Regarding carcass traits, the similarity between BGNE and BFNE heifers is also due to the same slaughter weight and HCW.

Bartoň et al. (2006) evaluated the performance and composition of the Hereford and Angus carcasses, which are part of the compostition of the Braford and Brangus breeds, respectively, and found no differences regarding ADG, slaughter weight and fat cover. Göncü et al. (2020) also did not observe differences in the fattening performance of Angus and Hereford steers.

CONCLUSION

Despite presenting lower carcass yield than Nellore heifers, crossed heifers are more efficient and present higher performance and better carcass fat cover than purebred Nellore heifers. Crossbreeding synthetic breeds, such as Brangus and Braford breeds, with the Nellore breed is an effective way to increase the productivity and efficiency of feedlot heifers in tropical regions.

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Felipe Cecconello Bento performed the experiment, analyzed samples, contributed to analyze the data, wrote the manuscript, reviewed and edited; Kamila Andreatta Kling de Moraes acquired the financial resources of this research, designed the study, analyzed the data, supervised the project and revised the manuscript for intellectual content. Cláudio Vieira de Araujo analyzed the data, performed the statistical analyzes and revised the manuscript for intellectual content; Vinícius Augusto Machado, Natan Leite Cecconello, Lorrayne Oliveira da Cunha, Jarliane do Nascimento Sousa, Karine Ribeiro dos Santos Naves, Juliana Candeiras Ortelam assisted in performing the experiment and laboratory analysis; Leandro Ferreira Moreno revised the manuscript for intellectual content; Eduardo Henrique Bevitori Kling de Moraes acted as a MSc supervisor of Felipe Cecconello Bento, designed the study, analyzed the data, supervised the project and revised the manuscript for intellectual content; All authors discussed the results and approved the final version of the manuscript.