PERFORMANCE, MORPHOLOGY AND CARCASS CHARACTERISTICS OF SINDHI BULLS ON AN OFFICIAL PASTURE-BASED GAIN PERFORMANCE TEST †

[DESEMPEÑO, MORFOLOGÍA Y CARACTERÍSTICAS DE LA CANAL DE TOROS SINDI EN UNA PRUEBA OFICIAL DE DESEMPEÑO DE GANANCIA BASADA EN EL PASTO]

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SUMMARY

Background. Beef cattle breeds need to be evaluated in pasture production systems. **Objective.** This study aimed to evaluate the performance, morphology and carcass characteristics of Sindhi bulls on pasture. **Methodology.** Twenty Sindhi bulls belonging to eight different herds of the state of Rio Grande do Norte were evaluated on an official weight gain test conducted by the Brazilian Association of Zebu Breeders (ABCZ). The experiment lasted for 294 days, including an adaptation period of 70 days. The animals were managed under a rotational grazing system, with periods of occupation of 20 days. Records of body weight and scrotal circumference measurements were taken every 56 days. Carcass evaluation and visual assessment were performed at the last weighing. Data were analyzed using descriptive analysis, simple linear correlation and means test. **Results.** The final body weight, average daily gain and scrotal circumference gain reached 304.60 kg, 0.482 kg/day and 10.29 cm, respectively. The loin eye area and intramuscular fat averaged 52.36 cm² and 1.25%, respectively. Significant and positive correlations between carcass ultrasound parameters were observed. Moreover, a positive and significant correlation between loin eye area and visual assessment was reported. There was no effect (P>0.05) of initial body weight on carcass characteristics, performance and visual assessment. **Implications.** Sindhi breed cattle are efficient in producing meat when fed exclusively with pasture, but need more genetic work that focuses on the deposition of adipose tissue in more valued regions of the carcass. **Conclusions.** The pasture-based gain performance test demonstrates the hardiness of the Sindhi breed, and the carcass evaluation validates the breed's aptitude for meat production and their precocity in depositing muscles.
Keywords: beef cattle; scrotal circumference; postweaning group; carcass ultrasound; Zebu cattle

RESUMEN

Antecedentes. Las razas bovinas productoras de carne deben ser evaluadas en los sistemas de producción de pasturas. **Objetivo.** El objetivo de este estudio fue evaluar el rendimiento, la morfología y las características de la carcasa de los toros Sindi mantenidos en pastoreo. **Metodología.** Durante la prueba oficial de aumento de peso realizada por la Asociación Brasileña de Criadores de Cebú (ABCZ), se evaluaron 20 bovinos Sindi machos de ocho rebaños diferentes del estado de Rio Grande do Norte. Durante 294 días de experimento, de los cuales 70 estaban destinados a la adaptación, los animales se mantuvieron en pastoreo, utilizando el método de almacenamiento rotativo, con períodos de ocupación de 20 días. Pesó y midió la circunferencia escrotal cada 56 días. La evaluación de la canal y la evaluación visual ocurrieron el último día de pesaje. Los datos se sometieron a análisis descriptivo, correlación lineal simple y prueba de medias. **Resultados.** El peso final, el aumento diario promedio y el aumento de la circunferencia escrotal fueron 304.60 kg, 0.482 kg / día y 10.29 cm, respectivamente. En la evaluación de la carcasa, se encontró un promedio de 52.36 cm² para el área del ojo del lomo y 1.25% de grasa intramuscular. Se verificó una correlación significativa y positiva entre las mediciones medidas en la evaluación de la carcasa por ultrasonido. Para los parámetros de rendimiento, el área del ojo del lomo y la evaluación visual, se encontró una correlación positiva y significativa. No hubo efecto (P> 0.05) del peso inicial sobre las características de la carcasa, los parámetros de rendimiento y la evaluación visual. **Implicaciones.** El ganado de raza sindhi es eficiente en la producción de carne cuando se alimenta exclusivamente con pasto, pero necesita más trabajo genético que se centre en la deposición de tejido adiposo en las regiones más valiosas de el cuerpo. **Conclusión.** Se concluyó que la prueba de aumento de peso evidencia la rusticidad de la raza Sindi y la evaluación de la carcasa reafirma la aptitud de la raza para la producción de carne y la precocidad de los animales al depositar los músculos.

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Palabras clave: ganado vacuno; circunferencia escrotal; eficiencia productiva; ultrasonido de carcasa; ganado cebú

INTRODUCTION

Cattle farming is one of the most important activities of Brazilian agribusiness, generating employment and income in rural areas. In 2018, it accounted for 8.7% of the national gross domestic product (ABIEC, 2019), with the largest commercial herd in the world (Carvalho and Zen, 2017). Beef production in Brazil is mostly pasture-based due to its low-cost characteristics (Souza *et al.*, 2016).

Although Brazil is the largest meat producer in the world (Gomes *et al*., 2017), the quality of meat should be improved by reducing the age at slaughter and the feed conversion of animals (Olmedo *et al.,* 2011). It is in this sense that Zebu cattle contribute to the progress of beef production, given their efficient use of forage sources and adaptability to adverse conditions. The combination of these factors results in improved animal performance under tropical conditions. Sindhi is a Zebu breed that has been perfectly responding to the stimuli of genetic selection, both regarding weight development, fertility, hardiness and other traits of economic relevance. These traits contribute to the widespread use of Sindhi cattle in show and commercial herds in Brazil (Leite *et al*., 2017).

According to Parckertp and Gallo (2012), weight gain tests are important selection tools for identifying superior genotypes using selection criteria such as weight gain, precocity, carcass yield and finishing, which are based on the genetic merit of animals. Therefore, they favor the identification of superior individuals based on individual characteristics. Weight gain tests are performed with animals from different herds in order to standardize contrasting environmental conditions; therefore, it is expected that the differences in performance between animals will reliably represent their genetic differences.

Among the benefits of weight gain tests, we can highlight the possibility of estimating the genetic merit of young animals, thus allowing early mating, classifying animals more accurately, reducing the generation interval and, consequently, increasing the genetic progress of herds (Faria *et al*., 2017). This study aimed to evaluate the performance, carcass characteristics and morphology of Sindhi bulls on an official pasture-based gain performance test.

MATERIAL AND METHODS

All animal management practices followed the recommendations of the National Council for Control of Animal Experimentation (CONCEA) for the protection of animals used for animal experimentation and other scientific purposes. (Protocol number 054/2017 - CEUA / UFRN).

This study was carried out at Fazenda Laranjeiras, located in the municipality of São José de Mipibu/RN, Brazil. The experimental area is located at the following geographic coordinates: 06°04'30.0” W longitude and 35°14'16.8” S latitude. Twenty Sindhi bulls belonging to eight different herds of the state of Rio Grande do Norte, sons of nine different bulls, were evaluated in an official weight gain test conducted by the Brazilian Association of Zebu Breeders (ABCZ), during 294 days. The animals were identified, vaccinated against parasites, drenched and allowed 70 days of adaptation to facilities and management. The grazing area was subdivided into seven paddocks of approximately 12 hectares, totaling 85 hectares. The paddocks were planted with Brachiaria (*Urochloa brizantha*), Pangola (*Digitaria Decumbens*), Tifton (*Cynodon sp*.) and Massai (*Panicum Maximum cv. Massai*) grasses. The animals were managed under a rotational grazing system, with periods of occupation of 20 days.

Records of body weight were taken following the regulations of the pasture-based gain performance test on the 1st and 70th days of adaptation, which was considered as the initial body weight and beginning of the test. Four intermediate weighings were performed at a 56 day-interval. The final weighing was performed after 294 days of the beginning of the test. The weighings were performed in the morning after 12-hour fasting of solids. Scrotal circumference (SC) was measured in centimeters by placing a measuring tape at the widest point of the scrotum after adequate ventrocaudal traction of the testes. At the end of the weight gain test, the bulls were visually assessed by EPMURAS metholody (Melo and Moura, 2012) – “*estrutura, precocidade, musculosidade, umbigo, raça e sexualidade”* in Portuguese – and scores were assigned to different parameters including body structure, precocity, muscling and navel - 1 to 6; phenotypic traits, feet and leg conformation and sexual characteristics - 1 to 4.

An ultrasound machine (ALOKA 500) was used to evaluate *in vivo* traits related to carcass composition. The device was equipped with a 12 cm, 5.0 MHz array transducer and a silicone coupler, allowing perfect coupling of the transducer with the animal's body. The area between the 12th and 13th thoracic vertebra on the left side of the animal was shaved prior to ultrasound measurements. The ultrasound probe was placed perpendicular to the muscle *longissimus dorsi*, between the 12th and 13th thoracic vertebrae, allowing the measurement of the loin eye area (LEA). The loin fat thickness was obtained 3/4 away from the medial side of the *longissimus dorsi*. For measuring the rump fat thickness (millimeters), the ultrasound probe was placed at the animal's croup region on the upper third of the muscle *biceps femuris*. Intramuscular fat (marbling) was obtained by placing the transducer parallel to the muscle *longissimus dorsi,* and was scored on a scale of 0 to 10. The ultrasound images were analyzed using BIAPRO PLUS® software.

After the end of the weight gain test, the following parameters were calculated for each animal:

I - Weight gain during the 224 days of the test, where: FW: Final test weight, in kg; IW: Initial test weight, in kg.

WG = FW - IW

II - Average daily gain, where: ADG: Average daily gain.

ADG = WG/224

III - Scrotal circumference, where: Initial SC: Scrotal circumference at the beginning of the test; Final SC: Scrotal circumference at the end of the test.

SC gain = final SC - initial SC

The initial age was adjusted to 250 days due to its wide variation. Moreover, the animals were grouped based on the initial weight, as follows: Group I: initial weight less than 180 kg; Group II: initial weight between 180 and 200 kg; Group III: initial weight between 200 and 215 kg; Group IV: initial weight above 215 kg. Descriptive statistics, variance analysis and means test were performed using SAS software. Tukey's test was used to compared means with a significance level of 5%.

RESULTS AND DISCUSSION

The means for initial weight and age were 152 kg and 250 days, respectively (Table 1). It is lower than that found by Silva *et al*. (2015) of 384.67 kg at 450 days, and Murta *et al*. (2019) of 384.7 kg at 390 days in Sindhi animals. This difference may be related to genetic and management differences, as well as to the effects of the environment before the weight gain test. The means for final weight and age of 304.60 kg and 545.43 days, respectively, were lower than that described by Yokoo *et al*. (2010) and Koury Filho *et al*. (2009), reaching 347.14 kg at 550 days and 330.91 kg at 523 days in Nellore animals, respectively.

The birth weight, with an average of 25.35 kg, was higher than the value of 20.53 kg reported by Santos (2011). It corroborates the fact that Zebu cattle have lower birth weights, in addition to the small size of Sindhi animals. The total weight gain of 108.14 kg during 294 days was similar to the value of 122.7 kg reported by Silva *et al*. (2015) for Sindhi animals confined after 342 days of study. It highlights the hardiness and remarkable efficiency of Sindhi cattle on pasture, with weight gains above those obtained in the feedlot.

The final scrotal circumference averaged 29.77 cm (Table 1), which is lower than the findings of Silva *et al.* (2015) and Murta *et al*. (2019). Both authors reported a mean scrotal circumference of 32.5 cm for young Sindhi bulls. The results of SC are moderate given the number of animals evaluated and the production system. The loin eye area (LEA) averaged 52.36 cm^2 (Table 2). Values of LEA are close to 60 cm^2 in Zebu beef animals aged 18-20 months, as reported by Souza *et al*. (2016). We can infer that the studied animals have great potential for meat production, since they already have reasonable muscle deposition rates in the carcass during the growing phase, even though *longissimus dorsi* is a late-developing muscle (Hashimoto *et al*., 2012).

The values of loin fat thickness (1.26 mm) and rump fat thickness (2.60 mm) were low because the animals were in full muscle growth. As a result, fat deposition in the carcass is not prioritized during this stage (Faria *et al*., 2009). Our results are similar to those of Lima Neto *et al*. (2009) in Guzerá animals, with values of 2.60mm and 3.60mm, respectively. Fat thickness is an indicator

Table 1. Descriptive statistics of weight, age, performance and scrotal circumference of Sindhi bulls on pasture.

Variable	Mean ± SD	Maximum	Minimum	CV (%)
Birth weight (kg)	25.35 ± 2.58	28	19	10.18
Initial weight (kg)	152.68 ± 25.23	192.98	102.04	16.52
Final weight (kg)	304.60 ± 39.13	373.89	225.51	12.85
Final age (days)	545.43 ± 25.44	579.59	497.47	4.66
Total weight gain (kg)	108.14 ± 19.70	144.56	75.27	18.21
ADG (g/day)	0.482 ± 0.09	1.01	0,336	18.21
Initial SC (cm)	19.49 ± 2.00	23.23	16.04	10.25
Final SC (cm)	29.77 ± 2.66	33.99	24.16	8.94
SC gain (cm)	10.29 ± 2.13	14.00	5.60	20.73

CV = coefficient of variation. SD = Standard Deviation. SC = scrotal circumference. ADG = Average daily gain.

Table 2. Descriptive statistics of carcass ultrasound parameters and visual assessment scores of Sindhi bulls on pasture.

Variable	Mean ± SD	Maximum	Minimum	CV
LEA (cm^2)	52.36 ± 7.01	71.03	41.67	13.39
Intramuscular Fat (%)	1.25 ± 0.63	3.42	0.51	50.79
Loin fat thickness (mm)	1.26 ± 1.23	3.55	0.00	99.72
Rump fat thickness (mm)	2.60 ± 0.84	4.06	1.01	32.26
Body Structure (BS)	4.05 ± 0.68	5.00	3.00	16.94
Precocity (P)	3.80 ± 0.41	5.00	3.00	10.79
Muscling (M)	2.95 ± 0.60	4.00	2.00	20.50
Navel score (N)	3.80 ± 0.89	5.00	3.00	23.53
Phenotypic traits (PT)	3.45 ± 0.60	4.00	2.00	17.53
Feet and leg conformation (FL)	3.25 ± 0.55	4.00	2.00	16.92
Sexual characteristics (S)	3.45 ± 0.60	4.00	2.00	17.53
Total of points	24.75 ± 2.02	29.00	21.00	8.17

LEA = Loin Eye Area. BS = Body structure. P = Precocity. M = Muscling. N = Navel. PT = Phenotypic traits. FL = Feet and leg conformation. S = Sexual characteristics.

of the degree of finish and is relevant to meat processing as it plays the role of thermal insulator. Moreover, the fat layer positively impacts the reproductive indexes of the herd due to its correlation with body condition score (Cattelam *et al.*, 2013). Intramuscular fat averaged 1.25% - 3.42%, which is similar to the findings of Lemos (2018), with variations of 1.49% to 5.92% in Nellore animals. Those results confirm that Zebu breeds have low intramuscular fat deposition potential and that there are high genetic variability and limited selection for this trait.

Body structure (BS) and precocity (P) scores averaged 4.05 and 3.80, respectively. These values are higher than those described by Faria *et al.* (2009) of 3.99 for BS and 3.85 for P. It allows us to state that the animals evaluated in this study had high muscle percentage and well-finished carcasses. The muscling score (M) averaged 2.95, which is lower than the found by Koury Filho *et al*. (2010) of 3.62. This low result can be justified by the fact that the animals were in the muscle growth phase, and, therefore, they have not yet expressed their full potential for this trait (Faria *et al*., 2009). The navel score (N) averaged 3.8, which is considered adequate according to Koury Filho *et al.* (2015). The observed positioning of the navel, foreskin and sheath is suitable for grazing animals, since this value is within the range (3 to 4) recommended by the ABCZ for Sindhi animals.

There was a significant, positive and moderate correlation between LFT and RFT; LFT and P; P and M (Table 3). Correlation coefficients between loin and rump fat thickness and visual precocity scores were positive and moderate, indicating that different sets of additive genes determine these characteristics. Moreover, the selection of one trait will result in the genetic progress of another characteristic.

Table 3. Pearson's correlation coefficients between carcass ultrasound parameters and visual assessment of Sindhi bulls on pasture.

	LEA	IMF	LFT	RFT	BS	P	M
LEA	1.00	ns	ns	ns	ns	ns	ns
IMF		1.00	ns	ns	ns	ns	ns
LFT			1.00	0.62	ns	0.51	ns
RFT				1.00	ns	ns	ns
BS					1.00	ns	ns
P						1.00	0.59
M							1.00

LEA = Loin Eye Area. IMF = Intramuscular Fat. LFT = Loin fat thickness. RFT = Rump fat thickness. BS = Body structure. P = Precocity. M = Muscling.

Subcutaneous fat is an important factor influencing meat quality and is the most variable component of carcass tissue, being greatly influenced by environmental conditions, especially nutrition. Rump fat tends to be deposited earlier than loin fat. It is a good indicator of early-maturing animals, especially those under grazing conditions (Feijó, 2019). Our ultrasound findings (LEA) confirm this statement, revealing extremely early-maturing animals. The correlations between precocity and muscling scores, as well as between precocity and navel scores, were positive and of moderate and weak magnitude, respectively. These results are similar to those of Taveira *et al*. (2016), who found similar correlation estimates between precocity and muscling scores (0.41) and between precocity and navel scores (0.10). Early-fattening animals tend to have satisfactory muscle development at young ages, although less precocious cattle with expressive muscle volume are not commonly found within a breed (Koury Filho *et al.,* 2009). Positive and significant correlations were observed between the following parameters: ADG and TWG; BW and IW; BW and FW; LEA and FW; IW and BS, FW and BS; BW and FL; (Table 4). The few significances found are possibly due to the low number of animals used in the study.

Table 4. Pearson's correlation coefficients between performance traits, loin eye area and visual assessment of Sindhi bulls on pasture.

	BW	IW	FW	ADG	SC	LEA	BS
BW	1.00	ns	0.51	ns	ns	ns	ns
IW		1.00	0.81	ns	ns	ns	0.52
FW			1.00	ns	0.72	0.50	0.48
ADG				1.00	ns	ns	ns
SC					1.00	ns	ns
LEA						1.00	ns
BS							1.00

BW = Birth Weight. IW = Initial test weight (kg). FW = Final test weight (kg). ADG = Average daily gain. SC = Scrotal circumference. LEA = Loin eye area. IMF = Intramuscular fat. LFT = Loin fat thickness. BS = Body structure.

Correlation estimates between carcass traits (LEA) and final weight were positive and moderate, demonstrating that LEA is influenced by factors such as animal size and feeding level (Fernandes *et al.*, 2010). The correlation between initial and final weight with BS was positive and moderate. Our findings are similar to that of Fernandes *et al.*, (2010) and Marques *et al*. (2013), who also found a significant and positive correlation between initial and final weight and BS (0.47 and 0.87, respectively). Thus, direct selection based on visual scores allows obtaining genetic gains for growth characteristics (Koury Filho *et al*., 2010).

Weight gain was moderately and positively correlated with scrotal circumference (Table 4), suggesting that selection for scrotal circumference should result in increased body weight at all ages (Siqueira *et al.*, 2013). However, we cannot infer the response of body weight after selection for scrotal circumference gain. Therefore, more studies are needed to clarify the correlation between scrotal circumference gain and body weight. The positive and significant correlation of scrotal circumference (P>0.05) with sexual characteristics demonstrates that the higher the scrotal circumference the greater the reproductive capacity of an animal (Andrighetto *et al*., 2011).

Besides the reproductive precocity, growth precocity also contributes to economic gains in cattle herds. Growth precocity can increase the efficiency of weight gain, reduce the finishing time on pasture and the amount of supplements used in order to obtain more efficient feed conversion rates and minimize costs and slaughter time (Jorge *et al*., 2016). Birth, weaning and yearling weights are the most studied weight-related parameters and are genetically correlated with reproductive characteristics, such as scrotal circumference (Siqueira *et al.*, 2013). There was no significant effect (P>0.05) of initial body weight on carcass characteristics, performance parameters and visual assessment (Table 5).

Pasture-based beef production is marked by periods of satisfactory weight gain, interspersed with periods of poor performance or weight loss. These factors are closely related to the seasonality of forage production and growth (Tonato, 2010), triggering possible nutritional stress. Animals subjected to those conditions show compensatory gain when fed better-quality diets (Muniz *et al*., 2014), although the response varies according to each animal (Almeida *et al*., 2010). This fact was observed in the studied animals, as they were submitted to different managements; thus, they started the weight gain test with different weights. For a complete compensatory growth, the animals should undergo short or medium restriction periods, and their recovery capacity decreases as the severity and duration of the restriction are increased (Almeida *et al*., 2010). Considering that there are regions where drought periods usually reach 7 to 8 months, such as the region in which this study was conducted, advances in knowledge and manipulation of compensatory growth becomes essential for understanding this phenomenon in pasture-based beef cattle systems.

Table 5. Means and coefficients of variation for carcass ultrasound parameters, visual assessment and performance traits of different groups of Sindhi bulls on pasture.

Parameter	Group I	Group II	Group III	Group IV	CV (%)
IMF	1.16[a]	1.23[a]	1.09[a]	1.51[a]	53.44
LEA cm²	47.98[a]	52.61[a]	56.54[a]	52.29[a]	13.08
LFT mm	1.16[a]	0.45[a]	1.11[a]	2.28[a]	91.63
RFT mm	2.64[a]	2.54[a]	2.33[a]	2.89[a]	34.07
BS	3.40[a]	4.20[a]	4.20[a]	4.40[a]	15.12
P	3.80[a]	3.40[a]	4.00[a]	4.00[a]	9.30
M	3.00[a]	2.60[a]	3.20[a]	3.00[a]	20.75
Initial SC	18.37[a]	19.38[a]	20.28[a]	19.91[a]	10.38
Final SC	29.56[a]	29.15[a]	30.22[a]	30.16[a]	9.59
TWG	106.17[a]	114.76[a]	116.91[a]	94.72[a]	17.68
ADG	0.474[a]	0.512[a]	0.521[a]	0.422[a]	17.67
Final weight	267.93[a]	311.16[a]	328.69[a]	310.64[a]	11.34

Group I (5 animals): initial weight less than 180 kg; Group II (5 animals): initial weight between 180 and 200 kg; Group III (5 animals): initial weight between 200 and 215 kg; Group IV (5 animals): initial weight above 215 kg.

CONCLUSION

The weight gain test demonstrates the hardiness of the Sindhi breed, and the carcass evaluation validates the breed's aptitude for meat production and their precocity in depositing muscles. However, the deposition of fat in different carcass regions still needs to be better manipulated by breeding programs for producing best-finished carcasses exclusively under pasture. It is essential to highlight the correlation between precocity and loin fat thickness, which is a fundamental characteristic for beef cattle that can be visually evaluated in Zebu cattle.

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Compliance with ethical standards. The research presents original data that are not submitted to other journals at the same time. All procedures followed the recommendations of the National Council for the Control of Animal Experimentation (CONCEA) under protocol No. 074/2017, approved by the Ethics Committee on Animal Use of Federal University of Rio Grande do Norte.

Data availability. Data are available with the corresponding author (Stela Antas Urbano, stela_antas@yahoo.com.br) upon resonable request.

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