Pre- Weaning traits of brahman calves under a dual-purpose management system in the tropics

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ABSTRACT

The objective of this study was to analyze factors associated with pre-weaning growth traits (e.g., weight and linear body measurements) and neonatal weakness in graded Red (RB, n=86) and Grey Brahman (GB, n=33) calves. Observed parameters included birth weight near body measurements. At birth, males were heavier (31.6 ± 0.9 kg 28.5 ± 0.8 kg; P<0.00(BW), weight at 210-d (W210), average daily gain from birth to 210-d (ADG), and multiple li2) than females, differences due to sire (P<0.001) were observed, and calves experiencing NW tended to be lighter than normal calves (29 ± 1.1 vs 31.2 ± 0.6 kg; P<0.06). At 210-d, males were heavier than females (124.7 ± 3.2 vs 111 ± 3.4 kg; P<0.007), cows in their second and fourth parities had the heaviest (P<0.001) calves. Heavier W210 (122.5 ± 3.4 vs 113 ± 3.1kg; P<0.01) and greater ADG (0.451 ± 0.01 vs 0.388 ± 0.01 kg/d; P<0.001) were found in calves born during dry season compared to those born during rainy season. Calves from second and fourth parity dams had greatest (P<0.01) ADG. Both at birth and 210-d., all linear body traits and body weight were highly correlated (P<0.001). Calves experiencing NW had reduced W210 (113 ± 4 vs 122 ± 2.6 kg; P<0.05) thorax circumference, hip height and dorsal length (P<0.001) compared to normals. Occurrence of NW was greater in RB than GB (P<0.005). Three sires were found to be associated with NW (P<0.005).

Key words: *Bos indicus*, Brahman, growth, neonatal weakness.

CARACTERÍSTICAS PRE-DESTETE DE BECERROS BRAHMAN EN UN SISTEMA

DOBLE-PRÓPOSITO TROPICAL

RESUMEN

El objetivo de éste estudio fue analizar factores asociados a características del crecimiento pre-destete y debilidad neonatal (NW) en becerros puros por cruce Brahman Rojos (RB, n=86) y Blancos (GB, n=33). Los parámetros observados fueron peso al nacer (BW), y a 210-d (W210), ganancia diaria de peso a 210-d (ADG), y varias medidas lineales. Al nacer, los machos pesaron más que las hembras (31,6 ± 0,9 vs 28,5 ± 0,8 kg; P<0,002), hubo diferencias debidas al toro padre (P<0,001), y los becerros con NW tendieron a ser más livianos que los normales (29 ± 1,1 vs 31,2 ± 0,6 kg; P<0,06). A los 210-d, los machos pesaron más que las hembras (124,7 ± 3,2 vs 111 ± 3,4 kg; P<0,007) y las vacas de segundo y cuarto parto tuvieron los becerros más pesados (P<0,001). Becerros nacidos durante la época seca tuvieron mayores W210-d (122,5 ± 3,4 vs 113 ± 3,1kg; P<0,01) y ADG (0,451 ± 0,01 vs 0,388 ± 0,01 kg/d; P<0,001) que los nacidos durante la época lluviosa. Becerros hijos de vacas en su segundo y cuarto parto tuvieron mayores ADG (P<0,01). Al nacer como a los 210-d, todas las medidas lineales y el peso corporal se hallaron correlacionados (P<0,001). A los 210-d, los becerros con NW fueron más livianos (113 ± 4 vs 122 ± 2,6 kg; P<0,05) y de menor talla en todas las mediciones (P<0,001) que los normales. La ocurrencia de NW fue mayor en RB que en GB (P<0,005) y se halló asociada a 3 toros (P<0,005).

Palabras clave: *Bos indicus*, Brahman, crecimiento, debilidad neonatal.

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INTRODUCTION

In Brahman cattle, red and grey coat colorations are usually thought of as a simple color variation within the breed. However, given the distinct compositions of *Bos indicus* and *Bos taurus* breeds in the formation of Red and Grey Brahman cattle [12, 13, 42], differences are suggested to exist in their productive performance. Pre-weaning growth traits such as weight, linear body measurements and factors associated with survival are logical starting points for assessing differences in performance between Red and Grey Brahman cattle.

Although extreme body mass and large frame negatively affect birth weight, nutritional requirements for maintenance, age at puberty and offspring survival [32, 55], selecting for growth traits generally has been shown to be a useful strategy to improve productive performance in both *Bos taurus* and *Bos indicus* beef cattle [22, 56].

In most tropical areas, cattle are raised under dual purpose systems of management. In such systems, cows are expected to produce both milk and a calf at weaning. To the producer, a dead calf is extremely detrimental because economical losses not only include an unsold calf but also the milk that the cow ceases to produce in the absence of her calf [2, 52]. Although almost 75% of world cattle population resides in tropical zones, animal production in these areas is often hampered by low genetic progress, lack of record keeping and reduced availability of scientific literature [53, 54]. Thus, information on linear body measurements of cattle in the tropics is lacking. In addition, factors affecting calf growth and survival, such as neonatal weakness, have not been adequately examined.

Conditions referred as "weak calf syndrome" and "dummy calf syndrome" were early reported [17, 35]. Although several etiologies have been suggested [8, 23, 47], causes of such syndrome are still unclear. Given its frequent occurrence in Brahman cattle, genetic factors have been suggested to be associated with neonatal weakness [4, 17, 26]. Neonatal weakness is a likely cause of calf morbidity and mortality [26]. In *Bos taurus* beef calves, neonatal weakness has been also associated with poor growth performance [58]. Despite its relevance for tropical and sub-tropical cattle production, research on this topic in the Brahman calf is scarce.

The objective of this study was to analyze the factors associated with pre-weaning growth traits (e.g., weight and linear body measurements) and neonatal weakness in Red and Grey Brahman calves.

MATERIALS AND METHODS

In order to analyze neonatal and pre-weaning traits, records of body weight and linear body measurements (e.g., thoracic circumference, abdominal circumference, hip-height, and dorsal length) at birth and 210-d, weaning weight corrected to 210-d, and neonatal health status were collected from 119 graded Brahman calves (Red Brahman= 86 and Grey Brahman= 33).

Animals were raised in a commercial farm located in Mene Grande, Zulia state, Venezuela, under a cooperative program with the College of Veterinary Medicine at the University of Zulia. This region is described as sub-humid tropical forest, with dry and rainy seasons extending from December to April and May to November, respectively. Average temperature, precipitation, and relative humidity are 28°C, 1400 mm/year, and

80%, respectively [25].

The herd was managed under a dual purpose management system. In this system, cows and calves are together only during milking hours (AM-PM). Cows and calves rotated separately in pastures of Alemán (*Echinocloa polystachia*), Guinea (*Panicum maximum*), Estrella (*Cynodon plectostachium*), and Tanner-grass (*Brachiaria radicans*). No other supplement, except an ad-libitum mix of minerals (trace and macro-minerals), was included in the daily diet of animals. Manual milking was performed twice/d, leaving one quarter for the calf.

Prepartum treatment (30-45 d before calving) of cows comprised vitamins AD_3E (500,000 IU, 65,000 IU and 50 mg, respectively; 8 mL, IM), levamisole 7.5% (8 mL, SQ), and pneumoenteritis bacterin (8 mL, SQ). A preventive herd health plan for local diseases (e.g., aftosa, leptospirosis) and parasites was in place. The herd was free of brucellosis and tuberculosis.

Reproductive management primarily involved artificial insemination (AI) using either frozen semen (from domestic and imported bulls) or natural breeding using purebred bulls produced by AI but raised at the farm. Calves in this study were sired by a total of fifteen (15) bulls. Data in this study were obtained from Brahman sired calves in which at least 7/8 of either Red or Grey Brahman breeding was accurately known from records.

Colostrum intake was assured by supervised suckling within the first 12 h after calving. Identification (ear tatoo), weight, health status and linear body measurement were recorded within 24 h of calving. At this time, each calf also received a neonatal treatment comprising of levamisol 7.5% (2 mL, IM), vitamins AD_3E + Se (2 mL, IM), and oxytetracycline 50 mg/mL (2 mL, IM).

Birth weight (BW) was determined using a portable scale with a capacity of up to 100 kg. Thereafter, a scale with capacity of 2000 kg was used for this purpose monthly. Weight at 210-d (W210) was adjusted. Linear body measurements were manually recorded at birth and monthly using a calibrated tape. Health status at birth was codified upon a general clinical evaluation at birth comprising 3 categories; good (no evidence of health problem), affected (unspecific or mild signs of disease, weakness) and bad (obvious health problems). To determine the general clinical well being of calves, health status was monthly monitored by a veterinarian. Neonatal weakness was defined as a clinical condition comprising one or more of the following: poor cognitive responses, poor suckling ability, slow mobility, and delay in standing [8, 26, 35]. Neonatal weakness was recorded as a yes or no event.

Statistical analyses comprised ANOVA models [41] that included independent variables such as breed of calf, sex, year, season, parity, weakness at birth, sire within breed, breed of calf by sex, breed of calf by season, sex by sire, and sex by season. The dependent variables were body weight and linear body measurements (e.g., thoracic circumference, abdominal circumference, hip height, and dorsal length) at birth and 210-d as well as average daily gain (ADG). Correlations and predictive regression equations to estimate BW and W210 were obtained using PROC CORR and PROC REG [41], respectively. Association between NW and variables such as season, sex, breed of calf, and sire were tested by Chi-Square using $P<0.05$ as the level of significance.

RESULTS

Correlations between body weight and linear body measurements

Correlations between body weight and linear body measurements are showed in TABLE I. Thoracic circumference and dorsal length were found to be good predictors of birth weight ($P<0.001$ and $P<0.01$, respectively). Similarly, thoracic circumference and hip-height were found to be good predictors ($P<0.003$ and $P<0.002$, respectively) of weight at 210 d of age.

The best predictive regression model for birth weight (BW) in this study was:

$$BW = -26.4 + 0.6\,(a) + 0.2\,(b) + e \quad r^2 = 0.49$$

where -24.6, 0.6 and 0.2 are model constants, a= thoracic circumference at birth (cm), b= dorsal length at birth (cm) and e = error term.

The best predictive regression model for weight at 210-d (W210) was:

$$W210 = -114 + 0.9\,(a) + 1.3\,(b) + e \quad r^2 = 0.64$$

where -114, 0.9 and 1.3 are model constants, a= thoracic circumference at 210 days of age (cm),

b= hip-height at 210 days of age (cm) and e= error term.

TABLE I
CORRELATIONS BETWEEN BIRTH WEIGHT, WEIGHT AT 210 D (KG) AND LINEAR BODY MEASUREMENTS (CM) IN RED AND GREY BRAHMAN CALVES

	BW	W210	TC B	TC210	AB	A210	HHB	HH210	DLB	L210
BW		.25 (P<.005)	.67 (P<.0001)	.36 (P<.001)	.55 (P<.0001)	.24 (P<.02)	.46 (P<.0001)	.29 (P<.008)	.48 (P<.0001)	.31 (P<.005)
W210				.75 (P<.0001)		.57 (P<.0001)		.75 (P<.0001)		.70 (P<.0001)
TCB				.29(P<.008)	.79 (P<.0001)	.24 (P<.03)	.53 (P<.0001)	.33 (P<.003)	.50 (P<.0001)	.29 (P<.009)
TC210					.25 (P<.02)	.74 (P<.0001)	.23 (P<.03)	.78 (P<.0001)		.74 (P<.0001)
AB							.44 (P<.0001)	.33 (P<.002)	.34 (P<.0001)	.28 (P<.01)
A210								.58 (P<.0001)		.71 (P<.0001)
HHB								.28 (P<.01)	.50 (P<.0001)	.71 (P<.0001)
HH210										.72 (P<.0001)
DLB										
DL210										

Legend: BW= Birth weight; W210=weight at 210 d; TCB= thorax circumference at birth; TC210=thorax circumference at 210 d; AB=abdominal circumference at birth; A210= abdominal circumference at 210d; HHB=hip-height at birth; HH210=hip-height at 210 d; DLB=dorsal length at birth; DL210=dorsal length at 210 d.

Birth weight (BW), 210-d adjusted weight (W210), and average daily gain (ADG)

Birth weights by breed, calf gender, and health status at birth are shown in TABLE II. Mean BW was 30.7 kg. Red and Grey Brahman calves did not differ in BW (P>0.05). Male calves were heavier (P<0.002) than females, and weak calves tended to be lighter (P< 0.06) than normal calves. The heaviest and lightest (P< 0.03) BW according sire within breed (LSM ± SE) were 35.3 ± 1.5 to 26.4 ± 4.8 kg for Red Brahman and 31.5 ± 2.2 to 28.8 ± 2.7 kg for Grey Brahman, respectively. Parity was not an important source of variation.

TABLE II
INFLUENCE OF BREED, SEX AND HEALTH STATUS ON BIRTH WEIGHT OF RED AND GREY BRAHMAN CALVES IN A TROPICAL ENVIRONMENT AND DUAL-PURPOSE MANAGEMENT SYSTEM. LEAST SQUARE MEANS ± STANDARD ERROR (LSM ± SE KG)

Breed	N	LSM + SE (kg)	Sex	N	LSM + SE (kg)	Health Status	N	LSM + SE (kg)
Red	82	30.5 ± 1.0^{NS}	Male	69	31.6 ± 0.9^{a}	Weak	36	29.0 ± 1.1^{c}
Grey	37	29.7 ± 0.8^{NS}	Female	50	28.5 ± 0.8^{b}	Normal	83	31.2 ± 0.6^{d}

($_{a, b}$) Means in a column with different superscript differ (P<0.002). ($_{c, d}$) Means in a column with different superscript tended to differ (P<0.06).

Weight at 210-d by breed, calf gender, season, health status at birth and parity are shown in TABLE III. Mean W210 for all calves in this study was 120.6 kg. Red and Grey Brahman calves did not differ in W210 (P>0.05). However, W210 was greater for male than female calves (P<0.0007) and for calves born during dry season compared to those that born during rainy season (P< 0.05). Parity influenced W210 (P< 0.005) and calves weak at birth were 9 kg lighter at 210-d compared to normal calves (P< 0.05).

TABLE III
BODY WEIGHT AT 210 D (KG) OF RED AND GREY BRAHMAN CALVES IN A TROPICAL ENVIRONMENT AND DUAL-PURPOSE MANAGEMENT SYSTEM (LSM ± SE)

Variable		N	LSM ± SE (kg)
Breed	Grey	35	120.9 ± 5.0^{NS}
	Red	79	118.7 ± 7.8^{NS}
Sex	Male	65	124.7 ± 3.2^{a}
	Female	49	111.1 ± 3.4^{b}
Season	Dry	55	122.5 ± 3.4^{c}
	Wet	59	113.3 ± 3.1^{d}
Health Status at Birth	Weak	31	113.0 ± 4.1^{e}
	Normal	83	122.0 ± 2.6^{f}
Parity	1	30	110.9 ± 3.6^{g}
	2	31	121.5 ± 3.6^{h}
	3	31	112.4 ± 3.4^{g}
	4	18	$134.8 \pm 4.8^{i\ j}$
	5	4	$109.9 \pm 9.8^{g\ k}$

(a, b) Means in a column with different superscript differ (P<0.007). (c, d) Means in a column with different superscript differ (P<0.01). (e, f) (g, h) Means in a column with different superscript differ (P<0.05). (g, i) Means in a column with different superscript differ (P<0.001). (h, i) (j, k) Means in a column with different superscript differ (P<0.02).

Average daily gain (ADG) at 210-d was influenced by gender, season, and parity. Mean ADG was 0.429 kg/d. Greater ADG was found in male than female calves (0.444 ± 0.01 vs 0.395 ± 0.01 kg/d, respectively; P< 0.01) as well in calves born during the dry season compared to those born during rainy season (0.451 ± 0.01 vs 0.388 ± 0.01 kg/d, respectively; P< 0.001). Likewise, calves born to cows in their fourth parity (0.490 ± 0.02 kg/d) had greater (P< 0.05) ADG than those from cows at first (0.399 ± 0.01 kg/d), second (0.423 ± 0.01 kg/d), third, (0.404 ± 0.01 kg/d) and fifth (0.385 ± 0.04 kg/d) parturition.

Linear body measurements at birth and 210-d

Female calves had greater thoracic circumference (TCB) at birth than males (70.4 ± 0.7 vs 68.9 ± 0.7 cm; P< 0.04). The greatest and smallest (P< 0.0001) TCB according sire within breed (LSM ± SE) were 70.4 ± 0.7 to 63.4 ± 1.0 cm for Red Brahman and 70.8 ± 0.7 to 67.0 ± 1.7 cm for Grey Brahman, respectively. Meanwhile, larger thoracic circumference at 210-d (TC210-d) was found in calves born during dry season compared to those that born during rainy season (113.7 ± 1.4 cm vs 107.8 ± 1.4 cm; P<0.003). Calves born weak had smaller TC210-d than normal calves (106.6 ± 1.8 cm vs 114.9 ± 1.1 cm; P<0.004). The greatest and smallest (P<0.04) TC210-d (LSM ± SE) according sire within breed were 118.3 ± 3.7 to 109.8 ± 1.8 kg for Red Brahman and 113.9 ± 4.3 to 108.2 ± 2.7 kg for Grey Brahman, respectively. Male calves tended (P<0.08) to have greater TC210-d than female (112.4 ± 1.5 cm vs 109.1 ± 1.4 cm, respectively). Differences in TC210-d between Grey and Red Brahman calves were only apparent (108.7 ± 1.7 cm vs 113.0 ± 1.3 cm; P>0.05).

Abdominal circumference at birth (AB) did not differ between Grey and Red Brahman calves (71.8 ± 1.1 vs 71.1 ± 1.0 cm, respectively). Variation due to sire within breed ($P<0.04$) on AB was found between Grey (70.5 ± 3.1 and 74.6 ± 1.9 cm) and Red Brahman (63.6 ± 1.8 vs 75.1 ± 3.1 cm) calves. Calves born weak tended ($P<0.08$) to have a reduced AB compared to normals (70.3 ± 1.2 vs 72.6 ± 0.7 cm, respectively). At 210-d, no differences ($P>0.05$) in abdominal circumference (A210) were found between Grey and Red Brahman calves (122.5 ± 2.3 vs 127.1 ± 1.7 cm, respectively). Calves which were weak at birth had a reduced ($P<0.008$) A210 compared to those which were normal (121 ± 2.4 vs 128.6 ± 1.5 cm, respectively). Likewise, calves had greater ($P<0.0002$) A210 during dry (129.9 ± 1.9 cm) than during wet season (119.6 ± 1.9 cm).

Hip height at birth (HHB) was higher in male calves than females (68.2 ± 0.5 vs 66.6 ± 0.5 cm, respectively; $P<0.01$). According sire within breed, highest and shortest ($P<0.002$) HHB were 70.1 ± 1.1 vs 64.3 ± 1.9 cm for Grey Brahman and 71.4 ± 1.9 vs 65.3 ± 1.0 cm for Red Brahman calves, respectively. No differences ($P>0.05$) in HHB were found between Red and Grey Brahman calves (68.4 ± 0.5 vs 66.4 ± 0.6 cm, respectively). Concerning hip height at 210-d (HH210), calves born during dry season were taller at hip than those born during rainy season (94.5 ± 1.0 vs 91.0 ± 1.0 cm, respectively; $P<0.01$). Likewise, calves born weak had shorter HH210 than normal calves (89.1 ± 1.2 vs 96.5 ± 0.7 cm, respectively; $P<0.001$). According sire within breed, tallest and shortest ($P<0.001$) HH210 for Grey and Red Brahman calves were 79.5 ± 3.6 and 94.4 ± 2.3 cm and 91.4 ± 1.2 and 105.5 ± 2.9 cm, respectively. Differences in HH210 between Red and Grey Brahman calves in this study were apparent only (95.2 ± 0.8 vs 90.4 ± 1.2 cm, respectively; $P>0.05$).

Dorsal length at birth (DLB) differed between male and female calves (72.3 ± 0.7 vs 70.4 ± 0.7 cm, respectively; $P<0.05$). According sire within breed, DLB tended ($P<0.08$) to differ between Grey (65.6 ± 2.7 to 73.9 ± 2.7 cm) and Red Brahman (65.9 ± 4.8 to 75.9 ± 1.5 cm) calves. No differences in DLB were found between Red and Grey Brahman calves (71.2 ± 0.9 vs 71.6 ± 0.8 cm, respectively; $P>0.05$). Greater dorsal length at 210-d (DL210) were observed during the dry season compared to rainy season (121.5 ± 1.6 vs 116.1 ± 1.6 cm, respectively; $P<0.01$). Calves born weak had shorter DL210 than normal calves (116.4 ± 2.0 vs 121.2 ± 1.2 cm, respectively; $P<0.04$). Differences ($P<0.01$) in DL210 due to sire within breed were found between Grey (107 ± 5.7 to 125.5 ± 3.7 cm) and Red Brahman calves (115.6 ± 2.0 to 129.4 ± 4.8 cm). No differences were found in DL210 between Grey and Red Brahman calves (116.7 ± 1.8 vs 120.8 ± 1.3 cm, respectively; $P>0.05$).

Neonatal weakness

Thirty percent (30%) of calves in this study were classified as weak at birth. However, after 1-2 weeks of supportive care (e.g. supervised suckling, individual housing, and medication as needed) most of these calves eventually became normal. Neonatal weakness was associated (P<0.005) with breed of calf and sire. Red Brahman calves had greater (32.6%, 29 out of 86) occurrence of this condition than Grey Brahman calves (21.2%, 7 out of 33). Most weak born calves were sired by three of the fifteen bulls in this study, and all of which were housed in AI centers. Five calves sired by these three bulls died during the perinatal period: one due to dystocia, another due to a congenital malformation (cleft palate), and three others due to weakness sequelae. No association was found between neonatal weakness and season of birth, or parity of dam.

DISCUSSION

Correlations between body weight and measurements

In agreement with our results, high and positive correlations have been found between weight and linear measures such hip height (r= 0.72), thoracic circumference (r= 0.77) and dorsal length (r= 0.70) in Brahman calves [28, 56]. Regarding hip height, large and positive correlations at weaning and 18m with weight were found by Vargas et al. [56]. It led these authors [56] to affirm that, if the breeding objective is to manipulate growth at 18 m, genetic progress could be obtained by selecting for hip height at weaning. Nevertheless, caution is needed because direct and maternal effects for hip height at weaning have been shown to be large and negative (r = -0.57). Thus, promoting extreme hip height by selection should be avoided in Brahman cattle to maintain acceptable milk production [29, 56].

Other tropical studies with crossbred dairy x zebu calves have also found high correlations between birth weight with thoracic circumference (r = 0.98), and body length (r = 0.69) at three and six months of age [36]. More recently, Alvarez et al. [1] determined that body length provides an accurate estimate of body weight. However, it should be stated that practical applications for these type of measures are breed specific [1].

Most cattle livestock operations from tropical zones lack of record keeping and are unable to afford scales. Thus, producing predictor equations upon the base of linear body measurements may represent a practical and cheap method to generate useful information for both genetic improvement and commercial activities. Although it is acknowledge a small sample size, the lack of scientifically supported information and the urgent need for improving cattle productivity in tropical regions could make this study useful.

Birth weight (BW), 210-d adjusted weight (W210), and average daily gain (ADG)

In agreement with our results, other studies on zebu cattle found male calves 2-3 kg heavier than female calves [3, 34, 38, 55]. The effect of calf gender on BW has been largely reported as attributed to a slightly prolonged gestation length by male fetuses [40] and their extended exposition to testosterone [6]. In addition, male calves are usually greater in all linear body traits than females, as shown in this study.

Association of sire with BW has been reported in other studies comparing *Bos indicus* and *Bos indicus* Sanga breeds [3, 10, 34]. Association of sire, frame size, and breed with BW has also been reported [3, 55]. Likewise, differences in BW of 3-10 kg due to sire such as that observed in this study are consistent with a previous study [34]. Beyond the genetic factors, differences in BW have been also associated to a relationship between sire, calf genotype and pre-partum oestrone sulphate (E_2SO_4) concentration [16, 51, 59].

The tendency of a reduced BW in weak born calves is not a rare event. Weak born calves are lighter than normal calves because they are usually smaller. As shown in this study, calves experiencing neonatal weakness were smaller than normal in all linear body measurements. High correlations between linear body measurements and BW were also demonstrated in the present and previous studies [28, 56]. In Holstein, neonatal weakness and intrauterine growth retardation were suggested to be associated with low maternal plasma E_2SO_4 and reduced placental development [31, 59]. Regarding Brahman cattle, no scientific information on this issue seems to be available.

To our knowledge, scientific information comparing Red and Grey purebred lines within the Brahman breed is not available. Consistent with our results, in F_1 Gray and Red Brahman x Hereford calves, no differences in BW (37 ± 0.7 k) were observed [33, 39]. Contrarily to our finding, other studies comparing several *Bos indicus* breeds and their crosses [3, 7] and *Bos indicus* influenced Sanga breeds (10) found differences in BW due to breed. Genetic aspects related to frame size are likely major reasons to explain differences in BW between breeds [55].

The finding of a lack of association between parity and BW in this study is not uncommon in *Bos indicus* purebred or crossbred catle [5, 11, 34]. However, some studies in Brahman

[3, 38] and *Bos indicus* influenced Sanga breeds [10] have found BW to be associated with parity. The association of parity with BW has been largely attributed to anatomical and nutritional factors. The smaller body size of first calving cows compared with mature cows [27, 46], and the partitioning of nutrients to cover both the requirements of the growing heifer and the developing fetus [20] are major factors that often result in lighter BW of calves from primiparous compared to multiparous females. Under tropical conditions, first parturition typically occurs after 3 years of age. Thus, we speculate that heifers calving at this age have nearly reached a mature weight and stature. Therefore, limitations imposed by nutrient partitioning and uterine environment on fetal growth are reduced.

With regarding W210, the effect of calf gender on weaning weight, with males being heavier than females has been largely reported. Therefore no discussion will be provided here. Likewise, previous studies also found season of birth to be associated with W210 [10, 34, 38]. Climatic influences on the availability and quality of pastures determine this type of effect on both cow and calf. Features of the regional distribution of rainfall and its effect on availability of pastures in this Venezuelan zone were described by Taylor et al. [50].

The association between parity and W210 has been previously reported [3, 38]. Because the demand of nutrients for growth is reduced as a cow matures, an increase in udder development and milk yield occurs [18, 43]. If not milked, this increase in milk is expected to be translated into greater calf weight gain. However, in this study, the association of increased W210 with parity did not follow a clear pattern. This might be attributed to confounded environmental (e.g., relationship among season, grass quality and milk yield) and human related factors (e.g., failures with manual milking and restricted suckling of calves). Other studies have failed to find an association between parity and W210 in Brahman cattle [55]. Under tropical dual purpose systems, contradiction exists among studies reporting the effect of parity on pre-weaning growth [21, 53].

In agreement with our finding, a previous study with *Bos taurus* beef calves also found significant differences in weight at 210-d between calves born weak and normal calves [58]. Nevertheless, in that study, calves born weak were 24.4 kg lighter than normal calves while in our study, such difference was only 9 kg. Given the importance of producing a heavy calf under both dual purpose and cow-calf beef operations, this is a situation in which the eventual lack of statistical significance should be contrasted with economic factors. We speculate that impaired suckling ability, limited colostrum consumption and reduced immunity might be reasons for differences in W210 between normal and weak born calves. Information on sequelae of neonatal weakness is not abundant.

The effect of season on ADG has been previously reported [10, 38] and it is one of the reasons for establishing prescribed breeding and calving seasons. Feed availability for both calves and dams is associated with season [3, 50]. It is therefore predictable that season will affects the ADG of calves. Seasonal differences in ADG in this study may be associated with the regional distribution of rainfall and related factors such increased incidence of disease and parasites. In this Venezuelan region, the annual distribution of rainfall often includes long periods of heavy rain, which cause a limited access to pastures for both cows and calves [50]. Similarly, in this particular zone, an increased occurrence of disease during the rainy season was previously reported [26].

Although the association of parity with W210 has been more recognized than ADG [3, 34, 38], these are closely related traits because an increase of W210 involves an increase on ADG. The parallel increase of milk yield with parity that occurs in cows [18, 43, 57] is a likely major reason explaining the positive association between parity and ADG observed in this study. No effect of parity on ADG was reported in *Bos indicus* influenced Sanga breeds [10]. However, these authors observed that strong environmental influences depressed the milking ability of cows of all ages.

Linear body measurements at birth and 210-d

This study clearly demonstrated that linear body measurements are largely correlated with body weight (e.g., BW and W210-d). Such high correlations were also reported in Brahman and crossbred calves [1, 28]. The magnitude of these correlations helps to explain the relationship between frame size and body weight reported by Vargas et al. [55, 56] and support the suitability of prediction equations in economically depressed zones.

Studies comparing Red and Grey Brahman calves on linear body measures are uncommon. As with our study, no differences in TCB were found between F_1 crosses of several zebu genotypes x Hereford [33]. In that study, values for TCB were within the ranges of our finding.

Previous studies with crossbred calves also determined a sire effect on TCB [33, 44]. Differences on linear body measures due to sire and breed can be explained by the genetic influence on frame size found by Vargas et al. [55, 56]. The effect of sire within breed on all linear measures explain the association of sire with dystocia and confirm the need for attention when breeding programs are planned.

Special reference should be given to the finding of neonatal weakness as a factor associated with a reduction of all linear traits at 210-d. How neonatal weakness can exert an influence on these linear traits is unknown, however, its depressor effect on body growth results evident. The strong association between all analyzed linear traits with body weight might provide another insight to explain why calves born weak had reduced weaning weights [55, 58].

Regarding the seasonal effect observed on all linear measures, strong environmental influences represented by feed management and herd management level were found to influence linear body measurements in Brahman [28]. According to Taylor et al. [50], the copious rainfall during the rainy season may limit the access to pastures in this Venezuelan locality.

The effect of calf gender on all linear measures may be a consequence of the prolonged exposition to testosterone [6] due to longer gestation by male fetuses [40] Uterine environment (mainly determined by maternal age and genotype), genetic and environmental factors may be also considered major effects on linear traits [15, 24, 34].

Neonatal weakness (NW)

In agreement with previous studies in Brahman cattle [4, 17, 26], a large percentage of calves in this study were categorized as weak. Although NW has been pointed out as a problem inherent to *Bos indicus* cattle [8], few have discriminated between Brahman and other genotypes [26]. However, NW has also been reported in Angus, Hereford, Chianina, Jersey, Holstein, Limousine, and Brown Swiss [26, 35]. More recently, peri-natal calf mortality in F_1 Red and Grey Brahman x Hereford calves was reported to occur without a relationship to dystocia or any pathology [39].

Inbreeding might be related to the occurrence of NW [26, 45]. Tropical herd management practices perpetuate the risk of inbreeding due to lack of records [3, 54] and the fashionable use of bulls and breeds [26]. The association of NW and sire observed in this study reiterates the probability of a genetic component in this condition.

As with other reports, no association was found in the present study between NW, season of birth [26] and parity. Some literature refers to anoxia-hypoxia due to exhausting parturition as an important cause of NW in calves [23, 55]. However, due to physiological and anatomical reasons [15, 33] dystocia is relatively infrequent in *Bos indicus* cattle [14, 25]. Hypothermia, dam teat size, starvation, nutritional factors, metabolic defects, congenital defects and prematurity have been suggested as factors associated with NW [9, 19, 23, 24, 48, 30, 59]. Despite these reports, the etiology of NW remains unclear.

Poor suckling ability of weak calves may result in inadequate colostrum intake. Thus, the most frequent causes for calf losses; poor immune-competence, subsequent illness (gastro-respiratory diseases), starvation, and other secondary causes [29, 34, 37, 49] may have NW as the underlying cause.

CONCLUSIONS

Given the high correlation observed between linear body measurements with body weight, designing predictor equations may benefit to economically limited farmers. Similarly, this type of information is useful for selection purposes. The high incidence of neonatal weakness suggests that it could be a major underlying cause of calf morbidity and mortality, especially if appropriate neonatal care is not provided. On the other hand, the costs associated with medical assistance and treatments to recover a weak born calf and the frequent depressed performance should be considered. The observed association between neonatal weakness, breed and sire demonstrates the need for a closer scrutiny of records in order to identify bulls and linages within the breed that may be responsible.

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