

Full Length Research Paper

Phenotypic characterization of the Guaymi breed in conservation centers of Panama

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Not all regions of the world have access to advanced means of analysis, such as molecular or quantitative genetics. In the absence of these or other means of selection, phenotypic analyses are used for breed differentiation as well as to evaluate productive aptitude. The objective of this work is to characterize morphometric variables and zoometric indices, as well as the morphological and phaneroptic characterization, of the Guaymi Creole cattle in conservation centers in Panama. The study included all available Guaymi creoles (98 females and 27 males) aged ≥ 3 years. The results indicate that the Guaymi breed has sexual dimorphism, little heterogeneity, and characteristics appropriate for areas where there is limited quality forage. The characteristics of the Guaymi breed correspond to a dolichocephalic profile, a longilineal and brachypelvic type. The indexes characterize it as having potential milk and meat-type aptitude, so it can be considered dual-purpose cattle in the absence of a directed selection program. The morphological characteristics are similar to those of *Bos taurus* breeds from Ibero-America and Africa.

Key words: Livestock, biodiversity, conservation, creoles.

INTRODUCTION

The presence of cattle in Central America and in the Americas dates back at least to the year 1521, when the Spanish crown agreed to the request of Pedrarias Davila, founder of Panama City and Governor of *Castilla del Oro*, to import 50 cattle and other supplies from the island of Santiago, currently Jamaica (Archivo General de Indias, 1521). These animals entered through Darien, where

they did not adapt well, but they reproduced very well in the cities of Panama, Natá, and Remedios. Panama became an indispensable point of gathering and distribution of cattle to the north through Central America and south during the conquest of the Inca Empire in present-day Peru (Villalobos et al., 2009).

Several studies have used microsatellites to genetically

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characterize creole breeds, including the Guaymi and Guabala breeds, as well as their genetic uniqueness, their importance, and their contribution to global biodiversity (Martínez et al., 2012; Ginja et al., 2013). Studies conducted in 2019 using uniparental markers confirmed the Iberian heritage (Spain and Portugal) and the contribution of African breeds such as the Gabu and Bafata of Guinea-Bissau, the Muturu of Nigeria, and the Egyptian breeds Baladi and Menoufis, giving a better frame of reference and a better understanding of the cattle migrations and introgression of genes to the New World (Ginja et al., 2019).

Not all regions of the world have access to advanced means of analysis, such as molecular or quantitative genetics. In the absence of these or other means of documentation, phenotypic analyses are used not only for breed differentiation but also to evaluate productive aptitude (Sierra, 2001). Morphometry is an essential tool to differentiate and select animal biotypes with statistical validity (Holgado et al., 2015). This technique is one of the most used by farmers, so it is valuable to consider in each population the morphometry that responds to a selection pattern and that is complementary to productivity (Ramónez Cárdenas et al., 2017). Indices such as hip height and hip width are relatively easy-to-measure indicators of skeletal development because these anatomical regions are easy to identify. Considering that skeletal development is progressive and relatively slow, few measurements are needed to accurately draw a valid growth curve for a particular animal (Cerqueira et al., 2017). Morphometric evaluation through descriptive statistics has been used to characterize indigenous and creole populations over time; examples of this are the Pyrenean breed in Spain, where differences were established based on its geographical origin; the morphometric variability of the Loja creole biotypes in Ecuador; and the analysis of the body conformation of the Argentine Creole (Martínez et al. 1998; Pastor et al., 2000; Aguirre-Riofrio et al., 2019).

Morphology refers to the form of an organism, that is, its external appearance (Griffin, 1962). Through morphological variables, the degree of homogeneity or heterogeneity that individuals within a population or race present can be determined (Canales 2014). Phaneroptic traits are also useful in the characterization of populations and are determined by qualitative variables (Herrera, 2002). Phaneroptics covers the study of the skin, such as ethnicity, wool, colors, horns, nails, and hooves by statistical treatments (Cevallos, 2012). Some authors have applied numerical taxonomy to the classification and morphological and phaneroptic characterization of Portuguese bovine breeds, a method that is a particularly important statistical tool in the study of traits (Sobral et al., 2002). The objective of this work is to characterize morphometric variables and zoometric indices, as well as the morphological and phaneroptic characterization of the Guaymi Creole cattle, in the conservation centers of the Agricultural Research Institute of Panama (IDIAP).

MATERIALS AND METHODS

The measurements were made considering animal welfare and health in Panama.

Sampling

The study was carried out on Guaymi breed from the Panamanian creole cattle conservation and use project, located in five research centers owned by the Agricultural Research Institute of Panama: This work included a population of 98 females and 27 males, kept under on-farm management system. The Pacifico Marciaga Experimental Station (CO), 8°27.389'N of latitude and 80°21.423'O of longitude, in the province of Coclé (n=27); Experimental Station Rio Hato Sur, 8° 21.149'N of latitude and 80°9.736'O of longitude (RH), located in the district of Anton, province of Coclé (n=33); Experimental Station Calabacito, 8° 14.709'N of latitude and 81° 4.765'O of longitude (CA), located in the district of San Francisco, province of Veraguas (n=28); the Experimental Station Arenas de Mariato, 7°21.933'N of latitude and 80°50.669'O of longitude (AM), located in the district of Mariato in southern Veraguas province (n=24); and the Carlos M. Ortega Experimental Station, 8°30.255'N of latitude and 82°17.722'O of longitude (GU), located in Gualaca in the province of Chiriquí (n=13). The research was undertaken in January 2019 to May of 2020.

Cattle age determination

Age of the sample cattle was determined by the records of each animal in conservation centers.

Morphometric variables

The study included all individuals over 3 years of age, males, and females, with good body condition. Live weight (LW) was measured using a kilogram scale. The following morphometric measurements were taken in centimeters, using a conventional measuring tape and a zoometric rod, both with an accuracy of ± 1 mm, following the methodology described by various authors (Rodríguez et al., 2001; Fernández et al., 2002; Martínez et al., 2007; Martínez, 2008; Parés-Casanova, 2009; Herrera and Luque, 2009): head width (HW), head length (HL), height withers (WH), hip height (RH), body length (BL), hip width (RW), hip length (RL), chest depth (CD), bicostal diameter (BCD), thoracic perimeter (TP), circumference of cannon (CC), and neck length (NL). From the zoometric indexes, four ethnological and five production indexes were generated: ethnological: cephalic index, $CEI = (HW/HL) \times 100$; thoracic index, $TI = (BCD/CD) \times 100$; pelvic index, $PEI = (RW/RL) \times 100$; body index, $BI = (BL/TP) \times 100$; productive: dactyl–costal index, $DCI = (CC/BCD) \times 100$; dactyl–thoracic index, $DTI = (CC/TP) \times 100$; transversal pelvic index, $TPI = (RW/WH) \times 100$; longitudinal pelvic index, $LPI = (RL/WH) \times 100$; relative depth of thorax index, $RDTI = (CD/WH) \times 100$; and Lateral Body Index, $LBI = (WH/BL) \times 100$.

Statistical analysis

The data collected were analyzed by least squares method through the general linear model procedure (Proc GLM) with the SAS University Edition package using Oracle Virtual Box 6.0. For the analysis of sex and locality effects (CO, RH, CA, AM, GU), analysis of variance was applied, where Y_{ijk} are the observations of the morphometric measures; Sx_i is the effect of sex; Lo_j is the locality effect; and e_{ijk} is the random error associated with the observations. Next, the least squares mean comparison test was applied when

Table 1. Descriptive statistics of morphometric variables of Guaymi Creole cattle (n= 125).

Variable	Mean	Minimum	Maximum	CV	SD
LW	318.57	201.00	576.00	22.04	71.04
HW	18.79	16.00	27.00	1.67	1.67
HL	47.08	40.00	55.00	2.94	2.94
WH	117.57	102.00	141.00	6.07	6.07
CD	64.40	45.00	85.00	7.62	7.62
TP	160.17	115.00	196.00	13.32	13.32
BCD	51.38	33.00	78.00	9.08	9.08
RH	123.17	107.00	139.00	5.59	5.59
RW	37.90	28.00	50.00	4.51	4.51
RL	42.98	30.00	55.00	4.04	4.04
CC	16.50	13.00	24.00	1.70	1.70
BL	128.82	105.00	161.00	9.40	9.40
NL	52.93	35.00	84.00	10.63	10.63

CV= coefficient of variation, SD=Standard Deviation. (LW) live weight, (HW) head width, (HL) head length, (WH) height withers, (RH) hip height, (BL) body length, (RW) hip width, (RL) hip length, (CD) chest depth, (BCD) bicostal diameter, (TP) thoracic perimeter, (CC) circumference of cannon, and (NL) neck length.

the analysis of variance was significant ($p < 0.05$). The interactions were omitted because they were not significant. In the analysis of the qualitative variables, frequency analysis was used using the same program. Phaneroptic components were considered, such as the color of the coat, types of fur and horns, and the morphostructure corresponding to the head, back, and rump. For the analysis of these characteristics, each variable and its type were recorded. For each characteristic, its definition and variability were considered by visual inspection, without using specific analytical techniques but following criteria for the preparation of breed standards (Rodero, 1994). The analysis of the qualitative variables used descriptive statistics and frequency analysis within SAS University Edition package using Oracle Virtual Box 6.0.

RESULTS

The morphometric variables of the Creole Guaymi cattle are described in Table 1. These variables presented Coefficient of variation (CV) values that were stratified as described (Pimentel, 1985). The variables with low CV were RH, WH, HL, BL, TP, and HW (4.54 to 8.88). Intermediate CVs were found for RL, CC, CD, and RW (9.41 to 11.90). High CVs were found for BCD, NL, and LW (17.67, 20.9, and 22.3). The CVs below 30% are considered acceptable (Gómez and Gómez, 1984; Patel et al., 2001). The CV values of BCD and LW were slightly higher than 20%, but the Guaymi breed showed phenotypic uniformity.

Most of the morphometric variables analyzed showed highly significant differences (Table 2) between males and females ($p < 0.001$). These were LW, HW, WH, CD, and TP. The variables RL and BL showed moderately significant differences ($p < 0.01$), and RH showed a lower degree of significance ($p < 0.05$). No differences were observed in BCD, RW, or NL. These results are like

those reported in creole cattle in southern Ecuador (Aguirre et al., 2019) where significant differences and sexual dimorphism were found between males and females in LW, TP, WH, CC, HW, and HL. However, the average weights in each sex were higher in the Guaymi breed. On the other hand, sexual dimorphism has been reported in the Creole of Santa Elena of Ecuador, but with higher LW, WH, TP, and CC than the Guaymi breed had (Cabezas et al., 2019).

The descriptive statistics obtained from the zoometric index are presented in Table 3. All the indexes showed moderate to high degrees of variability, but they did not exceed 23%. The lowest CV was observed in LPI (6.45), and the highest value was observed in TI (22.55). The values reported in the Guaymi agree with the profile of dolichocephalic animals observed in Ibero-American creole landraces (Aguirre et al., 2019).

The TI, with a value of 81.19, classified these cattle into the longilineal type, compatible with dairy animals (Dubuc, 1991). The PEI of 88.4 gave the Guaymi a brachypelvic-type profile (Contreras et al 2011). This index provides information on the proportion of the pelvic canal, and in the case of the female, it is related to the trait of calving ease. In the case of the Guaymi creole, it would be expected that the breed would present risks in the peripartum period; however, with the birth weights of females and males of 27 kg and 28 kg, respectively, the risk of dystocia is low (Villalobos-Cortés et al., 2012). The BI in Guaymi cattle was within the range of dairy breeds, 78-83 cm (Dubuc 1991). The results of two indices related to milk suitability, DTI and DCI, were measured, and they were 10.3 and 33.1, respectively. The value reported in the DCI of the Guaymi also shows a dairy vocation due to the correlation between fine bone

Table 2. Descriptive statistics of the morphometric variables used in Guaymi Creole cattle by sex.

Sex	Females				Males				p
	Var	Mean	Min	Max	SD	Mean	Min	Max	
LW	306.7	201.0	439.0	57.3	359.8	246.0	576.0	96.1	***
HW	18.4	16.0	27.0	1.4	20.1	18.0	27.0	1.9	***
HL	46.7	40.0	52.0	2.6	48.4	45.0	55.0	3.5	***
WH	116.4	102.0	129.0	5.2	121.8	112.0	141.0	7.1	***
CD	62.8	45.0	75.0	7.1	69.9	55.0	85.0	6.8	***
TP	158.6	115.0	184.0	12.4	165.6	146.0	196.0	15.2	***
BCD	52.9	37.0	78.0	9.3	46.1	33.0	67.0	5.9	ns
RH	122.9	107.0	138.0	5.6	123.9	114.0	139.0	5.7	*
RW	38.6	28.0	50.0	4.1	35.3	30.0	45.0	5.0	ns
RL	42.3	30.0	50.0	3.7	45.4	40.0	55.0	4.3	**
CC	15.9	13.0	18.0	0.9	18.6	16.0	24.0	2.1	***
BL	127.9	105.0	145.0	8.4	132.0	118.0	161.0	11.9	**
NL	48.3	35.0	60.0	3.7	69.0	41.0	84.0	11.3	ns

Min = minimum value, Max = maximum value, SD=Standard Deviation. (LW) live weight, (HW) head width, (HL) head length, (WH) height withers, (RH) hip height, (BL) body length, (RW) hip width, (RL) hip length, (CD) chest depth, (BCD) bicostal diameter, (TP) thoracic perimeter, (CC) circumference of cannon, and (NL) neck length. p: probability value < F: *p < 0.05; **p < 0.01; ***p < 0.001; ns = not significant.

Table 3. Descriptive statistics of zoometric indices of Guaymi Creole cattle.

Variable	Mean	Minimum	Maximum	CV	SD
CEI	39.98	34.00	60.00	8.37	3.35
TI	81.19	50.70	130.00	22.55	18.31
PEI	88.40	66.70	125.00	10.11	8.94
BI	80.52	69.64	98.61	6.13	4.93
DCI	33.11	20.50	51.50	20.17	6.68
DTI	10.32	8.33	13.04	7.89	0.66
TPI	32.22	25.00	40.00	9.89	3.19
LPI	36.53	28.90	45.50	6.45	2.36
RDTI	54.73	40.70	63.60	9.73	5.32
LBI	91.51	79.30	100.00	5.06	4.63

CV= coefficient of variation, SD=Standard Deviation. (CEI) cephalic index, (TI) thoracic index, (PEI) pelvic index, (BI) body index, (DCI) dactyl–costal index, (DTI) dactyl–thoracic index, (TPI) transversal pelvic index, (LPI) longitudinal pelvic index, (RDTI) relative depth of thorax index, (LBI) lateral body index.

structure and the productive capacity of this breed, although it has not been subjected to any selection or improvement program. Likewise, DCI shows this ability, as TP was about 10 times the CC (Aparicio, 1974). Regarding the aptitude towards meat production, TPI and LPI were measured, and they had mean values of 32.2 and 36.5, respectively. The TPI was slightly below the ideal of > 33, while LPI was in the appropriate range, it should not exceed 37, (Parés-Casanova, 2009; Aguirre et al., 2019). The RDTI, corresponding to the Alderson depth index, was 54.7, which is considered good since it exceeded 50 (Parés-Casanova, 2009). No significant sex effects were observed, except in CEI, DCI, and DTI. The

DTI was 39.55 in females and 49.10 in males (p = 0.022). This index, as it is not influenced by environmental or management factors, is important as an ethnological indicator of origin and of the relationship between species or races (Parés, 2006; Parés-Casanova, 2009). The DCI was 10 cm different between males and females (30.96 vs. 40.56, p = 0.0021), and DTI was 10.06 in females and 11.21 in males (p < 0.0001). In both indices, there are differences between sexes in the Creole of Santa Elena, with values slightly higher than those of the Guaymi breed (Cabezas Congo et al., 2019).

The morphometric variables showed highly significant differences between locations (p < 0.0001). Most

Table 4. Morphological variables related to the head of the Guaymi Creole cattle.

Description	Variables	Frequency	Percentage
Cephalic Profile	Straight	109	87
	Concave	14	11
	Convex	2	2
		125	100
Horned Position	<i>Procero</i>	1	1
	<i>Ortocero</i>	47	37
	<i>Opistocero</i>	77	62
		125	100
Hook Type	High	70	56
	Medium	30	24
	Low	25	20
		125	100
Horn shape	Lyre	102	82
	<i>Cornivuelto</i>	11	9
	<i>Rueda</i>	3	2
	<i>Bizco</i>	4	3
	<i>Brocho</i>	1	1
	<i>Playero</i>	2	2
	<i>Cornipaso</i>	2	2
		125	100
Horns direction	Forward	42	34
	Upward	80	64
	Horizontal	3	2
		125	100

Cornivuelto: tips of the horns backwards; *Rueda*: fairly wide circle; *Bizco*: tip of the horn lower than the other; *Brocho*: closed horns; *Playero*: horns open wide apart and straight out; *Cornipaso*: tips out.

variables were above the mean in the regions of Gualaca (LW, HL, WH, CD, RW, and BL), Arenas de Mariato (HW, WH, RL, CC, and NL), and El Coco (TP, BCD and RH). The Arenas region presented the highest value of NL, because it had the largest proportion of males. The zoometric indices, except for CEI (a variable not influenced by the environment), all showed significant differences ($p < 0.0001$). These variables had certain distribution patterns throughout the evaluated regions. CEI, DCI, and DTI were higher in the Arenas de Mariato region; TI and BI were higher in Calabacito; the LPI was higher in El Coco; and PEI, TPI and RDTI were higher in Gualaca.

Among the quality traits, the horns showed a predominance of white in the body and black in the tip (62%), followed by gray (26%). Guaymi cattle showed a diversity of colors in their coat: 52% of the evaluated cattle presented an overo color (two colors), 22% mixed color (more than two colors), 15% yellowish-white color,

and a minority a red (8%) or a black coat (3%).

Regarding the morphological traits, all the observed specimens of the Guaymi breed had horns (100%), ears in the horizontal direction, and a total absence of a hump, a similar to *Bos taurus* breeds, particularly in creole breeds in America, both in males and in females (Centellas et al., 2008; Rojas, 2014; Cevallos et al., 2016). A dewlap was seen in all animals evaluated, a sign of adaptation to hot climates.

The morphological variables related to the head, such as the cephalic profile and the position, type, shape, and direction of horns, are presented in Table 4. The 87% of the animals presented a straight cephalic profile, 62% of the horns were in the opistocero position, 56% were of the high hook type, 82% were lyre-shaped, and 64% had an upward direction (most common horn shape in Figure 1).

Regarding the morphological features related to the lumbar region and buttock area, 80% of the population



Figure 1. Lyre-shaped, the most common horn shape in Guaymi cattle.

had a straight back, 20% the saddled type. Regarding the shape of the buttock, 87% were classified as straight and 12% concave.

DISCUSSION

The Guaymi Creole cattle had many different morphometric variables from those reported in Manabí Creole (Cevallos et al., 2016). They were similar in live weight, height withers, and thoracic perimeter; lower in head length, head width, chest depth, bicostal diameter, and hip height; and higher in circumference of cannon. The overall means of live weight, thoracic perimeter, head width, and head length were higher and those of hip length, hip width, and body length lower than the values reported in Lojano Creole cattle in Ecuador (Aguirre et al., 2019). The live weight, thoracic perimeter, and head length were higher and head width, height withers, hip length, and body length lower than those reported in Peru in the creole cattle of the National Park, Huarascan-Ancash (Delgado et al., 2019). High values of thoracic perimeter, hip length, height withers, and hip height but similar values of body length and hip width and lower values of head width and head length were observed in the Guaymi Creole cattle than the Casanare Araucano biotype (Salamanca and Crosby, 2013). The Limonero Creole of Venezuela has shown higher values of live weight, hip height, height withers, head length, thoracic perimeter, body length, head width, circumference of cannon, chest depth, hip width, and bicostal diameter than the Guaymi Creole, but hip length was lower (Contreras et al. 2011).

Among the analyzed zoometric indices, cephalic index was lower than that reported in the Limonero Creole of Venezuela, the Manabí and Lojano creoles of Ecuador (Contreras et al., 2011; Cevallos et al., 2016; Aguirre et al., 2019), but it was higher than that reported in tropical dairy Creole in Veracruz, Mexico (Canales, 2014) and

Colombian Creole Casanare of Colombia (Salamanca and Crosby, 2013). The thoracic index was higher than that reported in Creole Limonero (Contreras et al. 2014) and Creole Lojano (Aguirre et al., 2019) and lower than that reported in Creole Casanare (Salamanca and Crosby, 2013). The pelvic index index in Guaymi cattle was higher than that reported in the Creole of Santa Elena (Cabeza Congo et al., 2019) and lower than that reported in the Manabí Creole (Cevallos et al., 2016). The body index was lower than those reported in the Creole cattle of Uruguay, the tropical dairy cattle of Veracruz, and Lojan Creole of Ecuador (Rodríguez et al., 2001; Contreras et al 2011; Aguirre et al., 2019). The body index in Guaymi was higher than those reported in the Bruna del Pirineus breed and the Limonero creole from Venezuela (Parés 2006; Contreras et al., 2011). The dactyl–thoracic index was similar to those reported in the Limonero Creole Contreras et al. (2011), the Manabí Creole Cevallos et al. (2012), and the southern Ecuadorian Creole (Aguirre et al., 2019). The transversal pelvic index was lower than that reported in Creole from southern Ecuador, Creole Lechero Tropical in Veracruz, and Limonero in Venezuela (Contreras et al., 2011; Canales et al., 2014; Aguirre et al., 2019). The longitudinal pelvic index was higher than that of Limonero and Tropical Dairy cattle (Contreras et al., 2011; Canales et al., 2014) and lower than those of Loja and Puna cattle (Rizzo Zamora et al., 2018; Aguirre et al., 2019). The relative depth of thorax index was higher than reported in the Creole of Santa Elena and Manabí in Ecuador (Cabezas Congo et al., 2019; Cevallos et al., 2016).

Lateral body index was higher than those reported in the Holstein (81.3), Hereford (88.2), and (86.4) in Uruguayo (Rodríguez et al., 2001), pointing to a dairy vocation, since a lower value of lateral body index implies more of a rectangular shape, which is not the case of the Guaymi lateral body index. Regarding the differences between the sexes, variations were reported in the nuclei of Casanare cattle in the Municipality of Arauca (Salamanca and Crosby, 2013).

The results on the difference between regions are similar to those reported in Colombia in a study on Casanare creole cattle (Salamanca and Crosby, 2013). The variations between the phenotypic traits between regions are due to environmental factors such as temperature (considered the most relevant), relative humidity, rainfall, geographic conditions, and food availability (Martínez et al., 2007; Ginés, 2009). In light of these results, phenotypic diversity of the breed between regions is observed, though the CVs are low, probably due to environmental effects, so the development of molecular characterization could complement the overall framework of the potential of this breed for the production of both meat and milk in regions where hardiness can be used with greater efficiency in pure breeds or in crossbreeding systems.

The Guaymi had similarly colored horns as Casanare cattle (Sastre et al., 2010) in which there are predominance of white in the body and black tips. Different results were reported in the study of Saavedreño cattle in Bolivia, which show a predominance of black color followed by caramel color (Rojas, 2014). In relation to the observed color of the coat, similar results in various proportions have been observed in other creole breeds, such as in Mexican Chinampo cattle (Espinoza et al., 2009) and Colombian Creole cattle Casanare (Rojas, 2014). Unlike Guaymi, the Saavedreña breed has a single coat color in 61% of individuals (Centellas et al., 2008). Much of the color palette observed in the creole breeds is seen in the Iberian breeds, such as the Berrenda en Negro, the Berrenda en Colorado, and the Retinta (Sánchez and Alonso, 1986).

The presence of a dewlap has been reported by several authors in various creole races adapted to tropical climates such as Creole Casanare, Saavedreño, Manabí, and Lechero Tropical (Sastre et al., 2010; Canales, 2014; Rojas 2014; Cevallos et al., 2016). The general analysis of this population shows that the majority have short and fine hair, possibly associated with the slick gene, which has been identified in other breeds, such as Romosinuano and Limonero (Bavera, 2004; Porto-Neto et al., 2018).

Guaymi-type horns are found in the Creole breed Casanare of Colombia, the Mexican Chinampo, the Saavedreño of Bolivia, and the Manabí of Ecuador, which have a predominance of horns with straight cephalic profiles, *opistocero* horns, and high hooks (Centellas et al., 2008; Espinoza et al., 2009; Sastre et al., 2010; Rojas 2014). On the other hand, the lyre-shaped horns also observed in Iberian breeds (Sánchez and Alonso, 1986) are like those reported in the Costeño con Cuernos and the Creole of Uruguay (Fernández et al., 2001; Ossa et al., 2011).

The characteristics of the back and the shape of the buttock that predominate in the Guaymi Creole are like those reported in the Costeño con Cuernos and Casanare of Colombia and the Manabí Creole of Ecuador

(Sastre et al., 2010; Ossa et al., 2011; Cevallos et al., 2016). Different results have been observed in the Creole bovine Saavedreño in Bolivia, which present a low saddled dorso-lumbar line (46%) and a buttock shape mostly concave (49%) and straight (46%) (Centellas et al., 2008). Recently, the influence of African breeds of *Bos taurus* origin, such as the Baladi and Menoufis of Egypt, the Bafata and Gabu of Guinea-Bissau, and the Muturu of Nigeria, has been identified in the creole breeds of America (Ginja et al., 2019).

It is likely that phaneroptic and morphological traits, such as those evaluated here, as well as the Iberian heritage demonstrated, have been an important part of the formation and adaptation of these breeds to the tropical climate and its resistance or tolerance to diseases. The combination of these phenotypic traits together with genomic information would provide a comprehensive overview of the Guaymi Creole cattle, as well as the rest of the creole breeds of Ibero-America.

Conclusions

This study reports 13 morphometric measurements and ten zoometric indices of the Panamanian Creole Guaymi cattle in various conservation centers in Panama. The results indicate that the breed can be considered dual-purpose cattle with an absent process of genetic selection. This study also describes the phaneroptic and morphological characteristics of the Creole Guaymi cattle, whose external features are like those of the Ibero-America and African breeds that are not humpbacked, making this work complementary to the works of other authors.

CONFLICT OF INTEREST

The authors have not declared any conflict of interest.

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REFERENCES

- Aguirre-Riofrio EL, Abad-Guamán RM, Uchuari-Pauta M (2019). Morphometric Evaluation of Phenotypic Groups of Creole Cattle of Southern Ecuador. *Diversity* 11(12):221.
- Aparicio G (1974). *Exterior de los animales domésticos*. Imprenta moderna. Córdoba, España 323p Available at: <https://www.studocu.com/es/document/universidad-alfonso-x-el-sabio/etnologia-y-gestion-empresarial-en-ambito-veterinario/>

- apuntes/exterio-de-los-animales-domesticos/2861427/view
- Archivo General de Indias (1521). Despacho para la ciudad de Panamá. Available by Portal de Archivos Españoles, Sevilla, Panamá 233, L.1, F. 288V-290R Available at: <http://pares.mcu.es/ParesBusquedas20/catalogo/description/376072?nm>
- Bavera GA (2004). El pelaje del bovino y su importancia en la producción. Editorial Río Cuarto Córdoba Argentina 1ra edición.
- Cabezas Congo R, Barba Capote C, González Martínez A, Cevallos Falquez O, León Jurado JM, Aguilar Reyes JM, García Martínez A (2019). Estudio biométrico del bovino criollo de Santa Elena (Ecuador). *Revista Mexicana de Ciencias Pecuarias* 10(4):819-836.
- Canales A (2014). Caracterización genética y morfológica de vacas de la raza Criollo -Lechero Tropical. Tesis. Maestría en Ciencia Animal. Universidad Veracruz. Mexico. Available at: <https://library.co/document/yjdm546y-caracterizacion-genetica-morfologica-vacas-raza-criollo-lechero-tropical.html>
- Centelles PD, Vaca RJL, Joaquín AJN, Peña CR, Pereira RJA (2008). Caracterización morfométrica del bovino Criollo de Saavedra. En: IX Simposio Iberoamericano sobre conservación y utilización de recursos zoogenéticos. Mar del plata. Argentina pp.145-152.
- Cerqueira J, Araujo P, Vaz PS, Cantalapiedra J, Blanco P, Niza R (2013). Relación entre Medidas Zoométricas en Vacas Holstein-Friesian y Dimensiones de Cubículos en Granjas Lecheras. *International Journal of Morphology* 31(1):55-63.
- Cevallos FO (2012). Caracterización morfoestructural y faneróptica del bovino criollo en la provincia de Manabí, Ecuador. Tesis Máster Universidad de Córdoba, España, Facultad de Veterinaria, Departamento de Producción Animal, Máster en Zootecnia y Gestión Sostenible: ganadería ecológica e integrada P 67.
- Cevallos FO, Barba C, Delgado JV, González A, Perea J (2016). Caracterización zoométrica y morfológica del ganado Criollo de Manabí (Ecuador). *Revista Científica* 26(5):313-322.
- Contreras G, Chirinos Z, Zambrano S, Molero E, Paéz E (2011). Caracterización morfológica e índices zoométricos de vacas Criollo Limonero de Venezuela. Instituto Nacional de Investigación Agrícola (INIA). Estación Local Carrasquero, estado Zulia, Venezuela 28(1):91-113.
- Delgado CA, García BC, Allcahuamán MD, Aguila GC, Estrada VP, Vega AH (2019). Caracterización fenotípica del ganado criollo en el Parque Nacional Huascarán-Ancash, Perú. *Revista de Investigaciones Veterinarias del Perú*, 30(3):1143-1149.
- Dubuc MW (1991). Zoometría. *Zootecnia General*. Ediciones Dumar, 3era, Edición- Caracas Venezuela 1:281-289.
- Espinoza J, Guevara J, Palacios A (2009). Caracterización morfométrica y faneróptica del bovino criollo Chinampo de México. *Archivos de Zootecnia* 58(222):277-279.
- Fernández EN, Martínez RD, Costas AM, Rumiano FJL, Género ER (2002). Determinación de grupos morfológicos en hembras de la raza bovina criolla argentina de distintos orígenes. *Archivos de Zootecnia* 51(194):211.
- Fernández G, Rodríguez M, Silveira C, Barba C (2001). Estudio étnico de los bovinos criollos del Uruguay II. Análisis de las faneras. *Archivos de Zootecnia* 50(190):119-124.
- Ginés R (2009). Variación morfológica. En: Valoración morfológica de los animales domésticos. Sociedad Española de Zootólogos pp. 141-165.
- Ginja C, Gama LT, Cortés O, Burriel IM, Vega-Pla JL, Penedo C, Sponenberg P, Cañón, J, Sanz A, do Egito AA, Alvarez LA, Giovambattista G, Agha S, Rogberg-Muñoz A, Lara M, BioBovis Consortium, Delgado JV, Martínez A (2019). The genetic ancestry of American Creole cattle inferred from uniparental and autosomal genetic markers. *Scientific Reports* 9(1):11486.
- Ginja C, Gama LT, Cortes O, Delgado JV, Dunner S, García D, Landi V, Martín-Burriel I, Martínez A, Penedo CT, Rodellar C, Zaragoza P, Cañón J, BioBovis Consortium (2013). Analysis of conservation priorities of Iberoamerican cattle based on autosomal microsatellite markers. *Genetics Selection Evolution* 45:35.
- Gómez KA, Gómez AA (1984). *Statistical procedures for agricultural research*. 2nd ed. John Wiley Inter Science, Hoboken, NJ, USA. Available at: <https://books.google.de/books?id=ZckqGwAACAAJ>
- Griffin DR (1962). *Estructura y función animal*. Compañía Editorial Continental S.A. Barcelona- España.
- Herrera M (2002). Criterios etnozootécnicos para la definición de poblaciones. Congreso de SERGA y III Congreso de SPREGA Madrid Libro de Actas pp. 41-48.
- Herrera M, Luque M (2009). Morfoestructura y sistemas para el futuro en la valoración morfológica. En: Valoración morfológica de los animales domésticos. Sociedad Española de Zootólogos. Coordinador: Carlos Sañudo pp. 79-109.
- Holgado FD, Ortega MF, Fernández J (2015). Evolución, con la edad, de diferentes medidas corporales en hembras bovinas de la raza Criollo Argentino. *Actas Iberoamericanas de Conservacion Animal* 6:178-183.
- Martínez MR, Fernández E, Abbiati C, Broccol AR (2007). Caracterización zoométrica de bovinos criollos: Patagónicos vs. Noroeste argentino. *Revista MVZ Córdoba* 12(2):1042-1049.
- Martínez RD (2008). Caracterización genética y morfológica del bovino criollo argentino de origen patagónico. Tesis doctoral. Valencia: Universidad Politécnica de Valencia, España. Available at: <https://dialnet.unirioja.es/servlet/tesis?codigo=18231>
- Martínez RD, Fernández, Rumiano FJ, Pereyra AM (1998). Medidas Zoométricas de Conformación Corporal en Bovinos Criollos Argentinos. *Revista Zootecnia Tropical* 16:2.
- Martínez AM, Gama LT, Canon J, Ginja C, Delgado JV, Dunner S, Landi V, Martín-Burriel I, Penedo MCT, Rodellar C, Vega-Pla JL, Acosta A, Alvarez LA, Camacho E, Cortés O, Marques JR, Martínez R, Martínez RD, Melucci L, Martínez-Velázquez G, Muñoz JE, Postiglioni A, Quiroz J, Sponenberg P, Uffo O, Villalobos A, Zambrano D, Zaragoza P (2012). Genetic footprints of Iberian cattle in America 500 years after the arrival of Columbus. *PLoS One* 7:e49066.
- Ossa G, Abuabara Y, Pérez JE, Martínez G (2011). El ganado Criollo colombiano Costeño con Cuernos (CCC). *Animal Genetic Resources* 48:101-107.
- Parés PM (2006). Relaciones entre diversas razas bovinas españolas y francesas obtenidas a partir del estudio cefálico por biometría. Libro de Actas. II Congreso Nacional de Carne de Vacuno. (Gijón, noviembre de 2006):166-172.
- Parés-Casanova P (2009). Zoometría. En C. Sañudo. Valoración morfológica de los animales domésticos. España: Sociedad Española de Zootecnólogos pp. 171-191.
- Pastor F, Picot A, Quintin F, Ruiz M, Sevilla E, Vijil E (2000). Características Zoométricas de La Raza Bovina Pirenaica En Función de Su Origen Geográfico. *Archivos de Zootecnia* 49:223-227.
- Patel JK, Patel NM, Shiyani RL (2001). Coefficient of variation in field experiments and yardstick thereof-an empirical study. *Current Science* 81(9):1163-1164.
- Pimentel Gomes F (1985). Curso de estadística experimental. II ed. rev. ampl. Piracicaba, Nobel pp. 56-76.
- Porto-Neto LR, Bickhart DM, Landaeta-Hernandez Antonio J, Utsunomiya YT, Pagan M, Jimenez Esbal, Hansen Peter J, Dikmen S, Schroeder SG, Kim Eui-Soo, SJ, Crespo, E, Amati N, Cole JB, Null DJ, Garcia JF, Reverter A, Barendse W, Sonstgard TS (2018). Convergent Evolution of Slick Coat in Cattle through Truncation Mutations in the Prolactin Receptor. *Frontiers in Genetics* 9:57.
- Ramón Cárdenas MA, Zhunio Samaniego LE (2017). Caracterización Morfométrica e Índices Zoométricos de los Grupos Raciales Bovinos Existentes en los Cantones Occidentales de la Provincia del Azuay. Bachelor's Thesis. Cuenca, Universidad de Cuenca, Facultad de Ciencias Agropecuarias, Carrera de Medicina Veterinaria y Zootecnia, Available at: <http://dspace.ucuenca.edu.ec/handle/123456789/28336>
- Rizzo Zamora LG, Muñoz Flores JE, Álvarez Franco LA (2018). Caracterización morfológica del bovino criollo de la isla Puná en Ecuador. *Actas Iberoamericanas de Conservacion Animal* 12:16-24.
- Rodero E (1994). Uso de marcadores genéticos en la caracterización de poblaciones raciales ovinas y caprinas autóctonas de Andalucía en peligro de extinción. Tesis doctoral, Departamento de Producción Animal. Universidad de Córdoba, España. Available at: <https://dialnet.unirioja.es/servlet/tesis?codigo=69124>
- Rodríguez M, Fernández G, Silveira C, Delgado JV (2001). Estudio étnico de los bovinos criollos del Uruguay: I. Análisis Biométrico.

- Archivos de Zootecnia 50(190):113-118.
- Rojas A (2014). Estudio morfométrico y fanerópticos del bovino criollo Saavedreño. Centro De Investigación Agrícola Tropical – CIAT Estación Experimental Saavedra. Santa Cruz de la Sierra, Bolivia. Available at: https://www.researchgate.net/publication/320508438_Caracterizacion_Morfologica_y_Faneroptica_del_Bovino_Criollo_Saavedreno
- Salamanca A, Crosby R (2013). Estudio fenotípico del bovino criollo Casanare biotipo Araucano. Análisis zoométrico. Zootecnia Tropical, 31(3):201-208 Available at: https://www.academia.edu/11098486/Estudio_fenot%C3%ADpico_de_l_bovino_criollo_Casanare_biotipo_Araucano_An%C3%A1lisis_zoom%C3%A9trico_Phenotypic_study_of_bovine_creole_biotype_Casanare_Araucano_Zoometric_analysis
- Sánchez A, Alonso A (1986). Catálogo de razas autóctonas españolas. II Especie bovina. Ministerio de agricultura, pesca y alimentación. Dirección general de la producción Agraria 219 p. Available at: https://books.google.com.pa/books/about/Cat%C3%A1logo_de_razas_aut%C3%B3ctonas_espa%C3%B1ola.html?id=UGfuKAAACAAJ&redir_esc=y
- Sastre HJ, Rodero E, Rodero A, Herrera M, Peña F (2010). Caracterización etnológica y propuesta del estándar para la raza bovina colombiana Criolla Casanare. Animal Genetic Resources 46:73-79.
- Sierra I (2001). El concepto de raza: evolución y realidad. Archivos de Zootecnia 50(192):547-564.
- Sobral MF, Cravador A, Navas D, Roberto C, Reis C, Lima MB (2002). Classification and morphological characterization of native portuguese cattle using numerical taxonomy. Revista portuguesa de Zootecnia 8(2):123-137.
- Villalobos-Cortés A, Martínez A, Vega-Pla JL, Landi V, Quiroz J, Martínez Rubén Martínez R, Sponenberg P, Armstrong E, Zambrano D, Marques JR, Delgado JV (2012). Relaciones entre los bovinos criollos panameños y algunas razas criollas de Latinoamérica. Pesquisa Agropecuária Brasileira 47(11):1637-1646.
- Villalobos-Cortés A, Martínez AM, Delgado JV (2009) Historia de los bovinos en Panamá y su relación con las poblaciones bovinas de Iberoamérica. Archivos de Zootecnia 58(224):121-129.