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Phaneroptic characterization of the criollo Mixteco cattle from Oaxaca, Mexico

Caracterización faneróptica del bovino criollo Mixteco de Oaxaca, México

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ABSTRACT

Criollo Mixteco cattle are considered a national heritage and a zoogenetic resource with high genetic variability, however, they are in danger of extinction. The objective was to characterize the phaneroptic variables of criollo Mixteco bulls from Oaxaca, Mexico, for conservation purposes. Thirty bulls aged 2.3 ± 0.8 years and weighing 248.8 ± 27 kg, located in the municipality of Huajuapan de León, Oaxaca, were evaluated. Twenty phaneroptic variables were determined by direct observation by the same technician. Data were analyzed by descriptive statistics including frequency measures. To determine differences between counts of the same variable, a Chi^2 test was performed. According to the results obtained, the phenotype of the criollo Mixteco cattle is characterized by a straight cephalic profile, absence of hump, and short length of dewlap, preputial sheath and tail. The horns are medium-sized and lyre-shaped. The ears are round and laterally oriented; the hooves and eyelids are black, and the coat, horn, and muzzle have a diversity of colors. It is concluded that the criollo Mixteco cattle population of Oaxaca, Mexico, possesses diversity in their phaneroptic characteristics.

KEY WORDS: Animal genetic resource, Phaneras, Zoometry.

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RESUMEN

Los bovinos criollos Mixteco son considerados un patrimonio nacional y un recurso zoogenético con alta variabilidad genética, sin embargo, se encuentran en peligro de extinción. El objetivo fue caracterizar las variables fanerópticas de toros Criollo Mixteco de Oaxaca, México, con fines de conservación. Se evaluaron 30 toros con edad de 2.3 ± 0.8 años y 248.8 ± 27 kg de peso, localizados en el municipio de Huajuapan de León, Oaxaca. Se determinaron 20 variables fanerópticas por observación directa por el mismo técnico. Los datos se analizaron mediante estadística descriptiva incluyendo medidas de frecuencia. Para determinar diferencias entre conteos de la misma variable se realizó una prueba de Chi^2. De acuerdo a los resultados obtenidos, el fenotipo del bovino criollo mixteco se caracteriza por tener un perfil cefálico recto, ausencia de giba, y longitud corta de papada, prepucio y cola. Los cuernos son de tamaño mediano y en forma de lira. Las orejas son redondas y orientadas lateralmente; las pezuñas y párpados son de color negro, y tanto la tonalidad del manto, cuerno y morro presentó diversidad de colores. Se concluye que la población de bovinos criollo mixteco de Oaxaca, México, posee diversidad en sus características fanerópticas.

PALABRAS CLAVE: Faneras, Recurso zoogenético, Zoometría

Introduction

The criollo Mixteco cattle of Oaxaca, Mexico, are considered a valuable animal genetic resource because of their adaptability to the hot-dry climate of the region and their hardiness, which allows them to survive in adverse conditions without the need for special attention. In addition, they are culturally important for the local communities, being a source of food and livelihood for the inhabitants of the Oaxaca Mixteca region, and an important symbol of their cultural identity (Méndez *et al*., 2002; López-Aguirre *et al*., 2023).

The conservation of landraces living in isolated areas or difficult environments is particularly important, as they are often adapted to low-input production systems, and have high genetic variability and phenotypic diversity (Lomillos & Alonso, 2020; Cruz-Clemente *et al*., 2024). These criollo cattle populations are managed by farmers and ranchers with low selection intensity, however, they may be under high natural selection pressure (FAO, 2012; Sponenberg, 2018); making them an alternative to the global trend of increasing livestock production, being compatible with environmental conservation and sustainable livestock production (FAO, 2012).

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From the point of view of the conservation of animal genetic resources for agriculture and food, phaneroptic characterization represents the basic study for the knowledge of the phenotypic diversity of the breed in the environment in which they live (Zayas *et al*., 2012). This characterization involves the development of phenotypic methodologies to identify and document the diversity of the different breeds and to determine their ecotype varieties according to the environment in which they live and their production environment, based on their observable attributes (Aguirre-Riofrio *et al*., 2019). Characterization includes all the activities and variables that can be carried out in the animal breeding nucleus, including the measurement of the phenotypic characteristics of the animals, interviews with farmers, and measurement of some aspects of the production environment (FAO, 2012). Phaneroptic and morphological traits are an important part of the formation and adaptation of these breeds to the tropical climate and their resistance or tolerance to diseases. Therefore, the present study aimed to characterize the phaneroptic variables of criollo Mixteco bulls from Oaxaca, Mexico, for conservation purposes.

Material and Methods

Geographic location of the study site

The study was conducted in 10 bovine production units (UP) belonging to the zoogenetic nucleus of the Oaxacan Mixteca region, in the municipality of Huajuapan de León, Oaxaca (17°48’14’’ N and 97°46’33’’ W), at an altitude of 1641 m.a.s.l. with a humid semi-warm climate with summer rains, average annual temperature of 20 °C and annual rainfall of 736 mm (INEGI, 2022).

Animal characteristics

Only bulls were selected to identify the phaneroptic characteristics of future breeding stock for conservation purposes of the criollo Mixteco bull breed (FAO, 2012). The selection comprised 30 bulls that met the Mexican criollo breed standard (Méndez *et al*., 2002; López-Aguirre *et al*., 2023). Non-probabilistic convenience sampling was performed. The average age and weight of the bulls was 2.3 ± 0.8 years and 248.8 ± 27 kg. The bulls were visually examined to ensure that they were free of pathologies or physical defects that could alter the phaneroptic measurements. They were kept under the usual management of bovine UP, which consists of a zootechnical management that is carried out at two times: during the dry season (March) and during the rainy season (October). In each one, the marking and identification of the hatchlings for sale is carried out, as well as some sanitary activities, such as vaccination against the bovine paralytic rabies (derriengue) and the administration of B complex vitamins. Management is transhumance type in communal territory covering 5,000 ha of native pastures, under a continuous extensive grazing system with free access to water.

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Phaneroptic characterization

Phaneroptic characteristics were taken as qualitative variables and were determined by direct observation by the same technician, according to the guidelines proposed by FAO (2012), which are:

- *Coat color: red, black, hosco, black Berrendo, red Berrendo;*
- *Muzzle color: pigmented, not pigmented;*
- *Eyelid color: pigmented, not pigmented;*
- *Hoof color: pigmented, non-pigmented;*
- *Presence of horns: present, absent;*
- *Horn color: white with black, white, black;*
- *Horn direction: upward, lyre-shaped, horizontal;*
- *Horn length: long, medium, short;*
- *Hair gloss: glossy, dull;*
- *Hair type: curly, straight;*
- *Hair size: short, medium, long;*
- *Ear shape: rounded, straight edges;*
- *Ear orientation: erect, lateral, drooping;*
- *Giba: present, absent;*
- *Cephalic profile: straight, concave, convex;*
- *Dewlap size: absent, small, medium, large;*
- *Backline profile: straight, slopes up towards the rump, slopes down from withers;*
- *Preputial sheath: absent, small, medium, large;*
- *Position of horns: procero (horn that originates in front of the nape of the neckline*

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and is directed towards the front and within the midline of the head), ortocero (horn that originates at the level of the nape of the neckline and is directed upwards almost perpendicularly and generally opens in the form of a lyre), opistocero (horn that originates behind the nape of the neckline and is directed upwards, or may be directed downwards and then come back up and continue backward);

- *Tail length: short (above the hocks), medium (around the hocks), long (below the hocks).*

Statistical analysis

Phaneroptic variables were analyzed by descriptive statistics including frequency measures. To determine differences between counts within the same variable, an individual Chi^2 (X^2) test was performed, which is described as follows:

Equation 1: $$x^2 = \sum \frac{(fo - ft)^2}{ft}$$

Where: fo= observed frequency of each phaneroptic variable; ft= expected frequency of the evaluated variable.

All analyses were performed with Statistical Package for Social Sciences software version 19 (SPSS V.19).

Results and Discussion

The phaneroptic characterization of criollo Mixteco bulls from Oaxaca, Mexico, defines them as animals with a straight cephalic profile, the presence of horns, total absence of humps, and both hooves and eyelids are black in color. The length of the tail is short, with an abundant and long tassel, characteristic of cattle that live in tropical areas where insects are abundant (FAO, 2012).

The preputial sheath is of short size and without umbilical fold, as described in other criollo cattle breeds where *Bos taurus* traits are still preserved, indicating little phenotypic effect provided by crossbreeding with *Bos indicus* breeds. (Sastre *et al*., 2010; Villalobos-Cortés *et al*., 2021). Another phenotypic variable that characterizes criollo Mixteco cattle are the ears, which are round and laterally oriented, as expressed in criollo de Rodeo, Chinampo, and Coreño (Hernández, 2012).

The presence of dewlap in the criollo Mixteco bull is short in size, similar to what has been described in several criollo breeds adapted to tropical climates, such as the criollo

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Casanare (Sastre *et al*., 2010), criollo Caqueño (Patiño-Quiroz *et al*., 2019), criollo de Rodeo and Chinampo (Hernández, 2012), and native Spanish breeds such as Berrendo en Colorado and Berrendo en Negro (Fernández *et al*., 2009).

The results in Table 1 show the absolute frequency, relative frequency, and X^2 value of statistically significant phaneroptic variables of criollo Mixteco bulls from Oaxaca, Mexico. For the coat color, the frequency of pigmentations is described in five shades ($p < 0.001$), of which, a tendency towards combined colors (< 70 %) is observed, with black Berrendo (53.33 %) and red Berrendo (16.67 %) being the most expressed. Coat coloration is similar to that expressed in Mexican criollo cattle, such as Chinampo from Baja California Sur (Espinoza *et al*., 2009), Rodeo from Chihuahua and Coreño from Nayarit (Hernández, 2012). It is important to note that the aforementioned criollo Mixteco cattle share certain phylogenetic characteristics (Ginja *et al*., 2019), suggesting that the criollo Mixteco could have genetic and phenotypic similarity with these breeds due to their common ancestry.

Regarding the horn color, there was a greater presence of white at the base with black at the tips (56.67 %) and black in its entirety (36.67 %). These results are similar to those observed in Casanare criollo (Sastre *et al*., 2010), Guaymi criollo (Villalobos-Cortés *et al*., 2021), criollo de Rodeo and Chinampo (Hernández, 2012). The horn position was observed in procero in 86.67 % (n=26) of the bulls, the remaining in ortocero position (n=4; 13.33 %); similar to what has been described in Lidia bulls (Lomillos & Alonso, 2020), and Serrana de Teruel (Vijil *et al*., 2009). On the other hand, 53.33 % of the bulls presented the horn direction upwards, 36.67 % in the form of a lyre, and the rest horizontally.

Regarding horn length, most of the animals presented medium and high horn length (53.33 and 40 %, respectively), and the rest of the bulls had short horn length. Similar results have been described in Serrana de Teruel (Vijil *et al*., 2009) and Criollo de Rodeo (Hernández, 2012) bulls. It has been described that the shape and length of the antlers are associated with the age of the population sampled (Parés i Casanova, 2009); in the present study, the animals had an average age of 2.3 ± 0.8 years, so it is inferred that their antlers are still growing.

The pigmentation of the muzzle was black in 90 % of the animals (n=27) and the rest with partial pigmentation (n=3; 10 %). These colors are characteristic of Mexican criollo breeds, such as Rodeo and Coreño (Hernández, 2012), and native breeds such as Cárdena Andaluza, Berrenda en colorado, Berrenda Negra, and Lidia (Fernández *et al*., 2009). The presence of this characteristic in the animals could be a form of adaptation to the adverse conditions of the tropical climate in which they live. In this climate, ultraviolet radiation is intense, making pigmentation of mucous membranes essential to protect them from injury caused by sun exposure (Montes *et al*., 2013).

Regarding the glossiness of the coat, 90 % of the individuals are reflected as glossy. Regarding the type of hair, 83.33 % of the animals had smooth hair, and the rest of the animals had curly hair, mainly on the forehead and neck area. The general analysis of the criollo cattle population shows that they have a short hair size, which could be associated with the mutation of the SLICK1 gene in the prolactin receptor, which gives the cattle a short coat and a greater

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capacity for thermoregulation (Sosa *et al*., 2022), as has been identified in other criollo breeds, such as Romosinuano and criollo Limonero (Porto-Neto *et al*., 2018). In addition, phenotypic variables such as the color of the skin and hair coat, as well as the size of the dewlap, ears, and horns, have been identified as adaptive mechanisms for the dissipation of excess body heat in tropical areas (FAO, 2012).

Tabla 1. Absolute frequency, relative frequency and X^2 value of phaneroptic variables of criollo Mixteco bulls from Oaxaca, Mexico.

Phaneroptic variable		Absolute frequency (Relative frequency %)	X^2 (p-value)
Coat color	Black Berrendo	16 (53,33)	21,33 (p<0,001)
	Red Berrendo	5 (16,67)	
	Hosco	3 (10)	
	Black	3 (10)	
	Red	3 (10)	
Horn color	White	2 (6,67)	11,40 (p=0,003)
	Black and white	17 (56,67)	
	Black	11 (36,67)	
Horn direction	Upward	16 (53,33)	8,6 (p=0,013)
	Horizontal	3 (10)	
	Lyre-shaped	11 (36,67)	
Muzzle color	Black	27 (90)	19,20 (p<0,001)
	Pigmented	3 (10)	
Horn position	Procero	26 (86,67)	16,13 (p<0,001)
	Ortocero	4 (13,33)	
Horn length	Short	2 (6,67)	10,40 (p=0,005)
	Medium	16 (53,33)	
	Long	12 (40)	
Hair gloss	Glossy	27 (90)	19,20 (p<0,001)
	Dull	3 (10)	
Hair type	Straight	25 (83,33)	13,33 (p<0,001)
	Curly	5 (16,67)	
Backline profile	Slopes down from withers	6 (20)	18,6 (p<0,001)
	Slopes up towards the rump	21 (70)	
	Straight	3 (10)	

$p < 0.05$ shows statistical differences.

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The backline profile of the criollo Mixteco bull is mostly characterized by being inclined towards the rump (70 %), typical of environmental breeds without human selection and of steep environments (Parés i Casanova, 2009), as expressed in criollo de Rodeo, Chinampo and Coreño (Hernández, 2012).

Once the criollo Mixteco bull from Oaxaca, Mexico has been phenotypically characterized, the opportunity opens up for future research, both reproductive studies to preserve the breed through the creation of germplasm banks, as well as productive and molecular genetic studies, since the combination of phenotypic traits together with genomic information would provide a global vision of the productive and reproductive characteristics of the criollo Mixteco bull from Oaxaca, Mexico.

Conclusions

The criollo Mixteco cattle breed from Oaxaca, Mexico, is characterized by its straight cephalic profile, uniform pigmentation of mucous membranes, hooves and its lyre-shaped antlers, as well as phenotypic diversity in coat colors; these phaneroptic traits are similar to Mexican and native Iberian criollo breeds. Molecular and genomic phylogenetic studies are recommended to determine the genetic variability of the breed and its subsequent use as a zoogenetic resource.

Authors' contribution

"Conceptualization of the work, R.L.A., F.M.P., V.H.S.L.; development of the methodology, R.L.A., F.M.P., V.H.S.L.; software management, R.L.A.; experimental validation, R.L.A., F.M.P., V.H.S.L.; analysis of results, R.L.A., F.M.P., V.H.S.L.; data management, R.L.A., F.M.P., V.H.S.L.; manuscript writing and preparation, R.L.A., F.M.P., V.H.S.L.; drafting, revising and editing, R.L.A., F.M.P., V.H.S.L.; project manager, F.M.P., V.H.S.L.; fund acquisition, R.L.A., F.M.P., V.H.S.L.

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Ethical statements

The Bioethics and Animal Welfare Commission of the Facultad de Medicina Veterinaria y Zootecnia of the Universidad Veracruzana approved the experimental procedures used in the animals of the present study (No. 009/21), which comply with the provisions of NOM-062-ZOO-1999.

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Conflict of interest

The authors declare that they have no conflicts of interest.

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